Tijuana Estuary – Friendship Marsh Restoration Feasibility and Design Study

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TIJUANA ESTUARY FRIENDSHIP MARSH RESTORATION
FEASIBILITY AND DESIGN STUDY

EXECUTIVE SUMMARY

The Tijuana Estuary – Friendship Marsh Restoration Feasibility and Design Study is a large-scale restoration plan for the southern portion of Tijuana Estuary, located in the southwestern corner of the United States in San Diego County, California. The project is a multi-disciplinary analysis, including both biological and physical sciences. The topics of analysis included:

- Geomorphic setting
- Climate
- Estuarine bathymetry, hydrology and hydraulics
- Sediment characteristics
- Coastal processes
- Hydrology of the Tijuana River and its tributaries
- Erosion and sedimentation characteristics of the Tijuana River and its tributaries
- Vegetation
- Wildlife
- Special status species/sensitive habitats
- Cultural resources
- Recreational resources
- Additional analyses and next steps

These analyses are presented in summarized form in this document and in their entirety in project appendices. In order to further condense the information presented in this document, this executive summary provides a brief summary of the major topics and concepts contained in each report section. This executive summary follows the general outline of the report by section.

SECTION 1.0 INTRODUCTION

Tijuana Estuary is one of the last relatively intact estuarine ecosystems in southern California. Despite this status, the estuary has been subjected to continuous degradation over time. Activities affecting the estuary include river channel modification, damming, renegade sewage flows from Mexico, unseasonal freshwater flows, and excessive erosion and sediment deposition. It has been estimated that as much as 60-80% of wetland habitats and tidal prism at Tijuana Estuary have been lost since the mid 1800s.

To reverse degradation and preserve the remaining resources at Tijuana Estuary, a restoration project has been proposed. The restoration plan proposes the restoration of wetland habitat in the southern arm of the estuary, transforming this area from a system that has lost much of its wetland functions to a functional and diverse wetland system. This restoration plan is supported by previous projects implemented to manage and control the sources of disturbance, especially sedimentation, which could result in further degradation.

SECTION 2.0 EXISTING CONDITIONS-OVERVIEW

The current Tijuana River Valley has evolved over millions of years, first cutting a deep river valley that was later filled by rising sea level. This drowned river valley evolved to form a broad floodplain in lower elevations, eventually resulting in a tidal estuary adjoining the Pacific Ocean. Today, Tijuana Estuary exists in an environment with limited and erratic precipitation, which normally occurs only during the winter. Floods in the Tijuana River are infrequent and brief, but often intense. During the periods between major floods, tidal channels typically accumulate sediment and may close intermittently, with potentially negative impacts to tidal habitats. The estuary is also affected by periodic coastal wave storms that may result in erosion of the barrier beach that shields the wetlands from continuous wave action.

Historic land uses at Tijuana Estuary, primarily agricultural and military activities, have combined with more recent watershed disturbances, such as dams and urban development in Mexico, to degrade the limited remaining undisturbed habitats of the estuary. In particular, the southern arm of the estuary has been impacted by sediment deposition and renegade sewage flows from the Tijuana River and tributary canyons. These disturbances have led to a loss of estuarine habitat in this portion of the estuary. Detailed photographic evidence of habitat degradation and loss is presented in this section.

This section also presents the historical ecology of the Tijuana Estuary as interpreted from maps ("T-sheets") created by the U. S. Coast Survey in 1852. Based on these maps and related references, Robin Grossinger of the San Francisco Estuary Institute interpreted the extent of estuarine habitat and generated draft digital data representing habitat in the area. Based on this analysis, it is estimated that approximately 400 hectares (988 acres) of estuarine habitat existed in 1852.

The 1852 maps were overlain on current aerial photographs of south San Diego Bay and Tijuana Estuary and on a 1986 habitat map of the estuary. Comparison of the 1852 maps and overlaid aerials and maps indicates that intertidal mudflat existed in the north, central and south arms of the estuary that has been converted to salt marsh or upland habitats from sediment deposition. Further examination of the 1852 map and overlaid aerial photographs and habitat maps of the modern day estuary also allows comparison of former and existing shoreline, tidal channels, tidal prism and upland habitats.

The extreme disturbance pressures and degraded state of the southern portion of the estuary make this area an obvious target for immediate restoration. The Model Marsh restoration project, completed in 2000, was the first phase of restoration in the southern arm and demonstrated the feasibility of a restoration program at this location. To protect existing and future restored estuarine habitats, the Goat Canyon Enhancement Project was constructed in 2005. This project, which included a system of sedimentation basins, was constructed to control a major source of sediment influx to the southern arm of the estuary. The Tijuana Estuary Friendship Marsh Restoration Feasibility and Design Study is a large-scale effort to restore further ecosystem function in the south arm of the estuary.

SECTION 3.0 RESTORATION GOALS

The primary goal of the Tijuana Estuary - Friendship Marsh Restoration Feasibility and Design Study is to restore, to as near natural conditions as possible, the southern portion of the estuary. The need for a restoration program was first noted in the Tijuana Estuary National Estuarine Sanctuary Management Plan (James Dobbin Associates, 1986). The management plan identified a number of management objectives to achieve the overall goal of restoration. These were adopted for the 1991 Tijuana Estuary Tidal Restoration Program (TETRP), a precursor to the current feasibility and design project.

In addition to the goals and objectives adopted by TETRP, the Southern California Wetland Recovery Program (SCWRP), a multi-agency group dedicated to wetland restoration in southern California, has developed a set of regional restoration goals. These goals and objectives are compatible with the goals and objectives of the proposed project. However, project-specific goals and objectives were developed for the Tijuana Estuary – Friendship Marsh Restoration Feasibility and Design Project. After some modification, these were adopted by the Technical Advisory Committee (TAC) and Research and Restoration Committee. The goals developed for this project include restoration targets while the objectives include steps to be taken to achieve those goals. Goals and objectives developed for the project include:

Goal 1. Increase tidal prism.

Objective: More than double the existing tidal prism of the estuary from the current 350 acre-feet to 750 acre-feet by expanding the area of subtidal channel, intertidal salt marsh, and marsh plain in the southern end of the estuary.

Goal 2. Restore areas of former salt marsh, tidal channel, and mudflat affected by sedimentation to the maximum extent possible.

Objective: Restore approximately 250-300 acres of the project area to coastal wetland habitat with roughly 25% restored to tidal channels and ponds, 50% to salt marsh habitat, and 25% to mudflat habitat.

Objective: Of the area to be restored, achieve a habitat mix of approximately 50% low marsh, dominated by cordgrass (*Spartina foliosa*), 25% mid-marsh, dominated by a mosaic of species, and 25% high marsh, dominated by glasswort (*Salicornia subterminalis*).

Objective: Design restored areas to reduce the potential for shifts in habitat type due to sedimentation by over-excavating some features, such as tidal channels and ponds.

Goal 3. Restore barrier beach and dunes.

Objective: Use suitable sediments excavated during the restoration to restore the barrier beach and dunes.

Objective: Stabilize the dunes through the removal of invasive species and planting of native species to prevent or reduce dune overwash and eastward migration.

Goal 4. Increase habitat for endangered species.

Objective: Create between 62.5 and 75 acres of low marsh habitat to support an estimated 16 –19 pairs of the federally listed and state-listed endangered light-footed clapper rail.

Objective: Increase mid- and high marsh by 31–37.5 acres each to provide additional high quality habitat for the state-listed endangered Belding's savannah sparrow, providing habitat for 198-240 pairs of this species.

Objective: Create 62.5-75 acres of channel habitat to provide foraging habitat for California least tern.

Objective: Create 62.5-75 acres of mudflat to provide foraging habitat for clapper rail and shorebirds.

Objective: Create undisturbed transition zone habitat for the recovery of the endangered salt marsh bird's beak and associated species (see Goal 5).

Goal 5. Increase area of undisturbed transition zone.

Objective: Expand the area of undisturbed transition zone habitat within the southern end of the estuary by creating a gentle elevational gradient from the landward edge of high salt marsh to provide a buffer between wetlands and uplands, support important insect plant pollinators, provide foraging and high tide refugia for birds, provide areas for the recovery of the federally listed endangered salt marsh bird's beak, and support a unique assemblage of plants and animals.

Goal 6. Incorporate a berm to prevent sudden loss of restored habitat from flood events.

The Tijuana River watershed has the potential to produce destructive floods. It was agreed that the project design should anticipate and be responsive to flooding to prevent either sudden or more gradual loss of restored intertidal sites due to flood hydraulics and/or sedimentation.

Goal 7. Incorporate research and adaptive management.

There is a long history of incorporating research on coastal wetlands into restoration projects at Tijuana Estuary. Such research has furthered the science of wetland restoration in general and has contributed significantly to the success of restoration projects at the estuary. Adaptive management has been applied to previous projects, such as the 20-acre Model Marsh, with lessons learned applied to this feasibility and restoration project. It was agreed that the project team would work with the research coordinator at the estuary and other researchers to incorporate research and adaptive management to future wetland restoration modules.

SECTION 4.0 RESTORATION ALTERNATIVES

The restoration alternatives presented in this study balance the preservation of existing habitat with the creation of new habitats. Restored wetland habitats will be protected from sediment-bearing flood waters by a protective berm located between the main channel of the Tijuana River and the project area. The need for this berm was determined by modeling of Tijuana River flood flows presented in Section 6.

Three specific restoration alternatives were developed (Figures 4-1 through 4-3). Alternatives A and C were designed to preserve different portions of disturbed, yet functional, habitat while also creating new, highly productive estuarine habitat. Alternative B was not designed to preserve existing habitat, but was designed to create the maximum area of high functioning estuarine habitat. For this reason, Alternative B was chosen as the Preferred Restoration Alternative.

During the winter of 2004-2005, sediment conveyed by flood waters originating in Goat Canyon Creek was deposited in an area of existing high salt marsh targeted for preservation in Alternatives A and C. As a result, preservation of that area was no longer relevant because the disturbed wetland habitats to be preserved no longer existed.

SECTION 5.0 COASTAL PROCESSES AFFECTING TIJUANA ESTUARY

In a balanced estuarine system, sediments may be deposited in channels by both riverine and coastal processes. Scour during ebb tides and during river flooding conveys sediments from the channels to the nearshore environment where they are distributed by ocean currents. Any interruption of this process can jeopardize the healthy functioning of the estuary. In semi-arid lands, the infrequent periods of scour associated with river flooding tend to allow a slow accumulation of sediment in the estuary channels and tidal inlets that can lead to tidal closure. Semi-arid land estuaries with small tidal prisms are especially vulnerable to inlet closure because the sediment flushing power of the ebbing tide is not sufficient to counteract sediment deposition that prevails during periods between floods.

Under natural conditions, there are brief periods of intense flow in the Tijuana River interspersed with long periods where the river does not flow and limited sediment and fresh water reaches the estuary. In most years, very little sediment is delivered to the estuary. Often decades pass before a major flood event brings a large deposit of sediment to the estuary and ocean. However, these rare but intense floods not only deposit sediments in the estuary. They also serve to scour the network of tidal channels that normally accumulate sediments during dry periods. These infrequent floods are essential to the long-term existence of the tidal channel network.

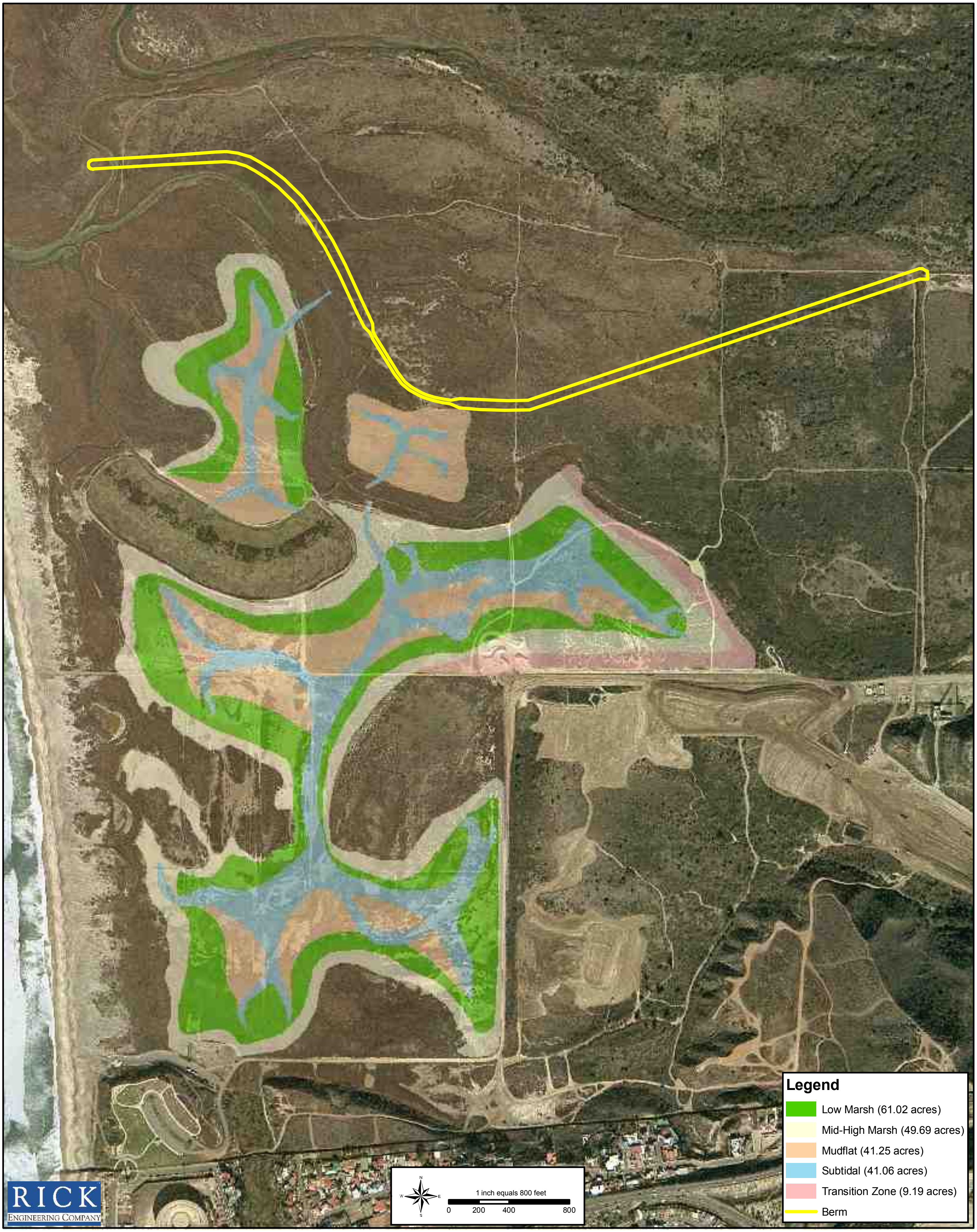


FIGURE 4-1 **Alternative A Restoration Plan and Habitat Configurations**

FIGURE 4-2 Alternative B (Preferred) Restoration Plan and Habitat Configurations

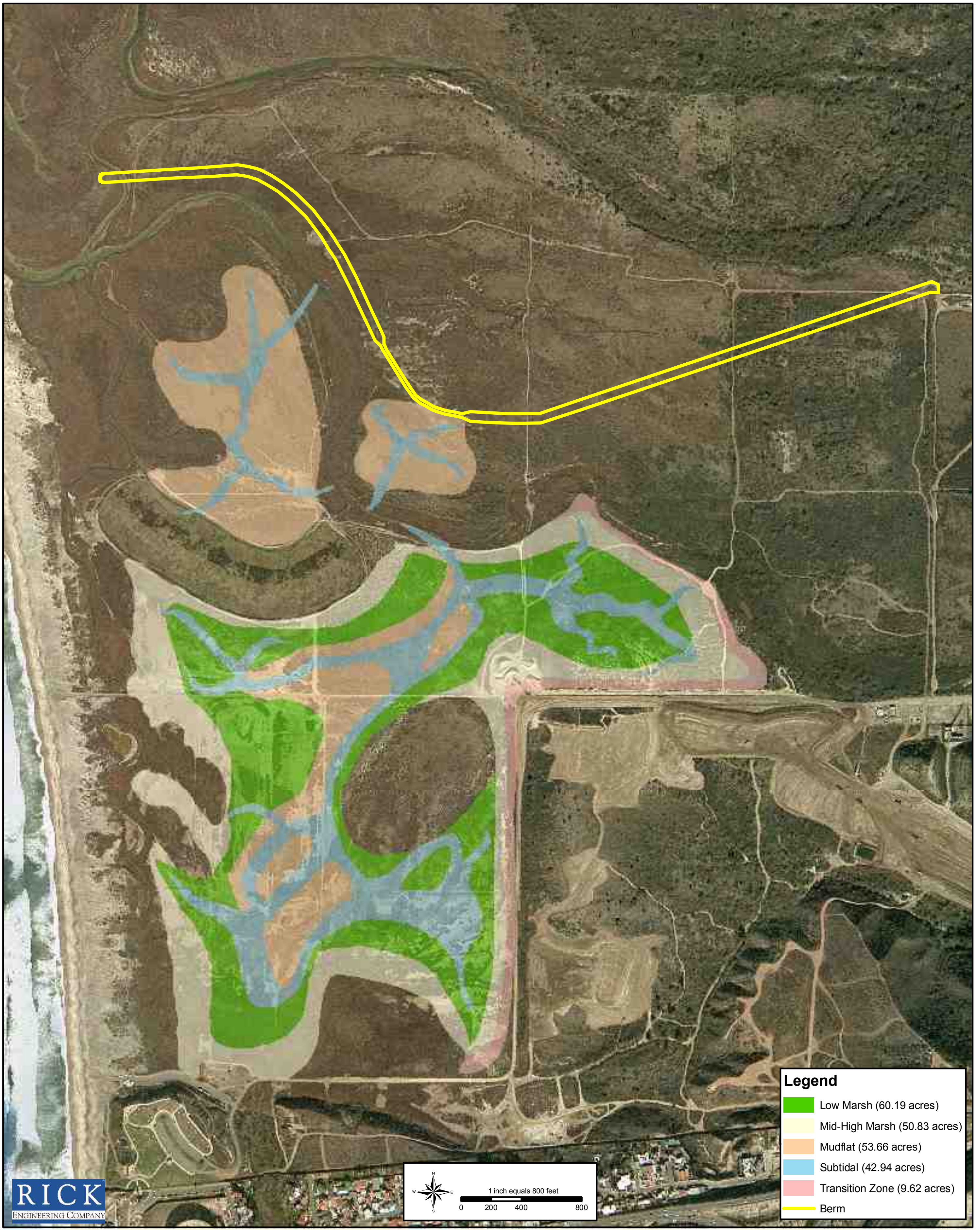


FIGURE 4-3 **Alternative C Restoration Plan and Habitat Configurations**

The physical processes affecting sediment deposition and scour at Tijuana Estuary have been disrupted by human-induced changes in the landscape. The damming of tributaries in the upper watershed captures and holds sediments that were historically delivered to the coast during floods. While sediment delivered to the estuary via the Tijuana River is depleted overall, rapid urban development and vegetation clearing within Tijuana, Baja California, Mexico, has resulted in unnaturally high sediment loads delivered directly to localized portions of the estuary (specifically the project area). These human influences have disturbed the sediment balance that maintains the Tijuana Estuary system.

The barrier beaches that front and protect Tijuana Estuary are periodically subject to intense wave erosion. This is produced when severe winter wave-storms approach the estuary from the southwest and interact with offshore islands and irregularities in the continental shelf to produce a region of focused wave erosion at Tijuana Estuary. These periodic events have resulted in dune over-wash that has deposited sand in the main channels and tidal inlet of Tijuana Estuary, further reducing the tidal prism.

Long-term studies show that sediments tend to be eroded from the dunes and beaches of the Tijuana Estuary region and deposited near Coronado Island. Under natural conditions at Tijuana Estuary, infrequent, but intense floods carrying high volumes of sediment, replenished the sediment deficit. However, damming of tributaries and other watershed modifications now trap the sediments normally delivered to the coast and barrier beaches. Without these sediment inputs, barrier beaches will tend to erode and may be breached during wave storms. This possible beach breaching could result in substantial damage to the estuary.

Climate changes associated with global warming also influence the ecosystem balance at the estuary. Warmer temperatures in the Pacific Ocean have resulted in a number of unusually intense El Niño (warm-wet) climate periods since 1978. Mean sea level has also risen in the modern era. Higher mean sea levels coupled with the expansion effects of warming water during intense El Niño periods result in a significant rise in the elevation of the highest tides at Tijuana Estuary. In addition, intense El Niño periods produce focused wave storms that batter the barrier beaches and dunes. These events will continue to contribute to increased erosion of the coastline at Tijuana Estuary.

All of these changes are predicted to result in a net loss of beach width, possible beach breaching and frequent tidal channel closure at the estuary. Under current conditions, many tidal channels and basins are already clogged with sediment and experience weak tidal flushing. Without intervention to restore tidal wetlands, the barrier beach is predicted to breach as early as 2045. If this trend continues, much of the estuary may be severely damaged, with portions of the estuary lost completely.

A restoration program involving the expansion of tidal prism and tidal wetlands, maintenance of these restored tidal channels, and delivery of excavated sediments to supplement adjacent beaches, is predicted to effectively halt the current deterioration of estuarine ecosystem function at Tijuana Estuary.

SECTION 6.0 TIJUANA RIVER FLOOD HYDROLOGY, EROSION AND SEDIMENTATION

As stated above, Tijuana Estuary is subject to sediment flushing during storms and deposition of littoral sand during tidal exchanges in the dry season. The major source of new sediment has been substantially reduced by dams constructed on major tributaries. The proposed marsh restoration is located in the floodplain of the Tijuana River south of the main channel and may have important hydrological impacts on the river channel, including flood level, river channel scour, and sediment delivery to the beach. In order to evaluate these impacts on the Tijuana Estuary, an erodible boundary model capable of simulating river hydraulics, sediment transport and river channel morphology changes was applied.

Effective and Ineffective Flow Area

The Tijuana River has been confined to a single channel that meanders across a broad floodplain. Flow velocities within the system are naturally higher within the main channel than in the overbank areas. Flow velocities are affected by bridges, road crossings and existing berms within the floodplain. Areas behind the berms may occasionally experience minor flow or may be submerged during an extreme flood. However, these areas do not contribute significantly to the conveyance of the flow discharge. In hydrologic terms, these areas are described as being outside of the effective flow area. By contrast, the effective flow is that area of the flood plain that conveys flood flows and sediment. Figure 6-2 shows the lower Tijuana River with a line delineating the effective flow area and the ineffective flow area.

In order to protect the restored marsh from potential damages caused by flow and sedimentation, a berm is proposed to separate the restored marsh from the effective flow area of the river channel (Figure 6-4). The berm is designed to keep both high flows and bed sediment from entering the restoration area. The alignment and design of the berm were determined by many trial modeling runs. An alignment that encroaches on the river flow could cause a rise in the flood level (backwater effects). On the other hand, an alignment outside the effective flow area would limit the area available for marsh restoration. Fortunately, backwater effects can be eliminated if a portion of the higher river flows is admitted into the marsh area through a weir. This would allow the berm to be aligned within the effective flow area.

The proposed weir would be located on top of the berm and centered at section 41.3. It would include the following features:

(1) Crest length: 700 feet.
(2) Crest elevation: Varies from 7.3 feet at the west end to 7.6 feet at the east end.
(3) Side slope: 3:1.

The weir would perform the following functions:

(1) Only floods higher than the 10-year flood level will enter the marsh area because the weir crest elevation (approximately 7.5 ft.) corresponds to the 10-year flood level.

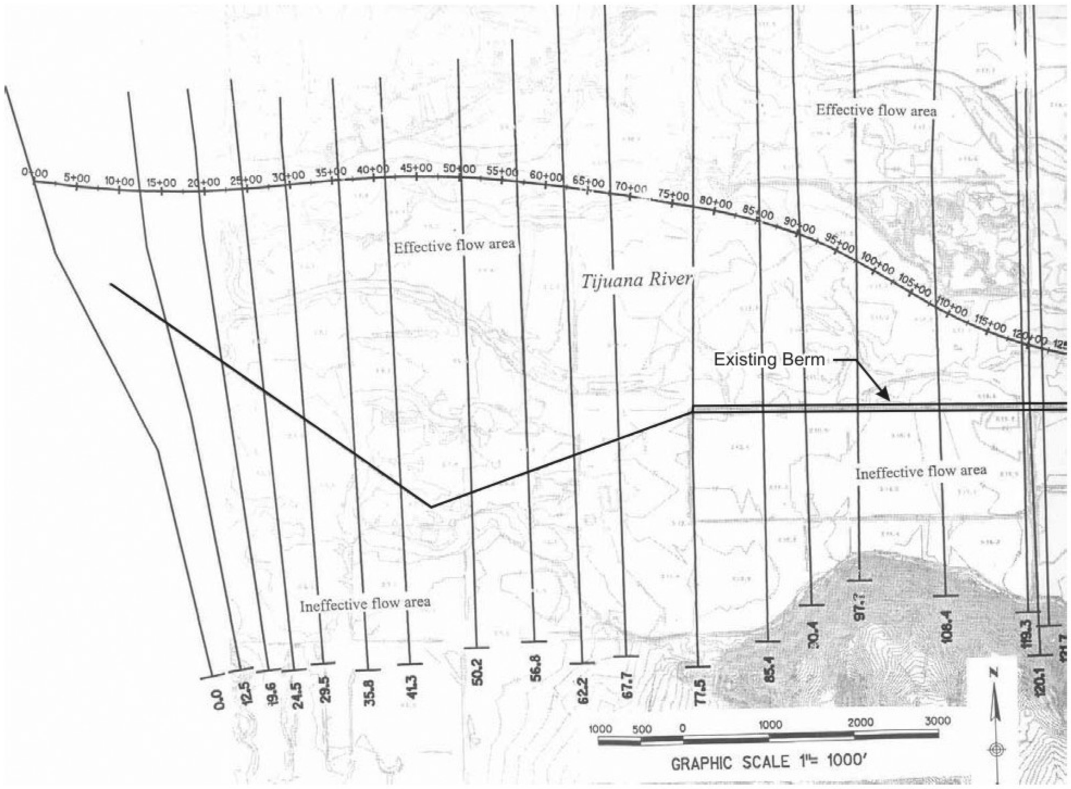


Figure 6-2. Lower Tijuana River Showing Effective Flow Area with Existing and Proposed Berm

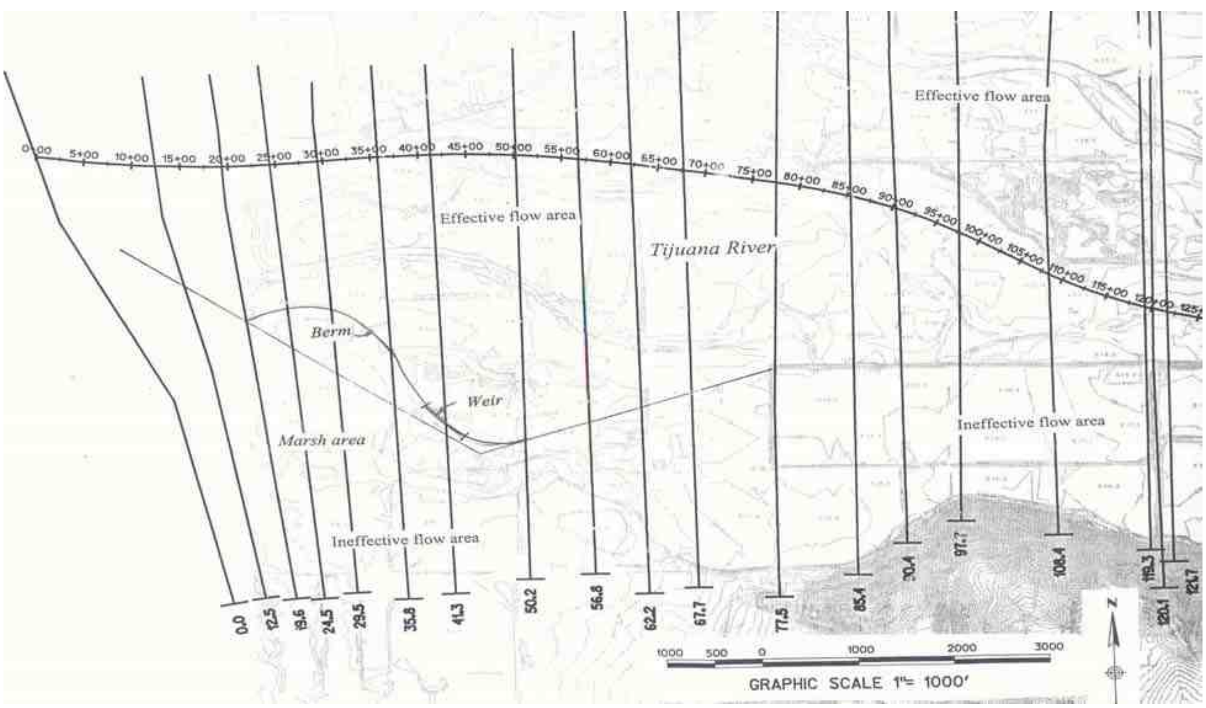


Figure 6-4. Lower Tijuana River Showing the Proposed Berm Alignment

(2) A small portion of higher floodwaters would leave the main channel and enter the marsh area to relieve backwater effects on the river channel. This partial flow has a maximum discharge of 14,600 cfs during the 100-yr flood (19.5 % of the 100-yr discharge for the river channel). As the flow enters the marsh area, it would spread out over a very large surface area and the average flow velocity in the marsh area would quickly drop below 3 feet per second. This velocity is considered to be a non-scouring velocity and, therefore, will not cause damage to the vast majority of marsh habitat.

No bed sediment will enter the marsh area beyond the berm because the weir crest elevation is above the adjacent river channel bed. Suspended sediment load and floating debris would be transported into the marsh during weir flows. However, this should not be a significant maintenance problem for the marsh for the following reasons:

(1) Weir flow would occur infrequently, generally once every 10 years because the weir will exclude all but the highest flood flows.

(2) The duration of weir flow would always be much shorter than the full flood duration. In addition, the volume of discharge over the weir would be very small during most of the overflow period.

(3) Only the finest portion of the suspended sediment load (the wash load) can be carried into the marsh. This wash load comprises a very small volume and tends to remain in suspension for long periods of time. Therefore, it is most likely to remain in suspension and be transported directly through the marsh channels, back to the main river channel, and subsequently the Pacific Ocean.

Floating debris will occur in flood flows, but because of the typically low water depth passing the weir, most large debris is unlikely to pass into the marsh. Small pieces of debris that do enter the marsh may also float directly out again. Remaining amounts of debris should not be significant.

Additional modeling was conducted to assess the effect of the restoration on scour and sedimentation patterns in the river as well as effect on channel and mouth geometry. The results show that the main river channel and river mouth geometry are not significantly changed by the restoration or the berm. Scour and sedimentation patterns throughout the river length are similarly unaffected, as are man-made structures such as bridges and roads.

Supplemental Hydraulic Analysis

Several projects are planned in the general vicinity of the Friendship Marsh restoration that could affect the project. Foremost among these is the 32-acre riparian restoration project proposed by the San Diego County Water Authority (SDCWA). That proposed restoration may include removal of a major berm that extends east-west along the south side of the Tijuana River. This berm is known locally as the AmSod Berm.

The removal of the AmSod berm could impact the design of the Friendship Marsh restoration. The protective berm and weir proposed for the Friendship Marsh restoration would connect with this existing berm. In order to assess the potential impact that removal of the AmSod berm would have on the Friendship Marsh, additional hydraulic analyses were conducted by the Rick Engineering Company.

Hydraulic analyses were modeled using HEC-RAS Version 3.1.3, a 1-dimensional model created by the U.S. Army Corps of Engineers to determine water surface elevations (WSELs), velocities and other hydraulic characteristics for natural or engineered channels.

Four scenarios were modeled:

- Alternative 1: (No-Action Alternative) Existing Berm Condition with Friendship Marsh Berm
- Alternative 2: (Preferred Alternative) Protected AmSod Condition with Friendship Marsh Berm
- Alternative 3: Alternative AmSod Condition with Friendship Marsh Berm
- Alternative 4: Existing Berms Removed Condition with Friendship Marsh Berm

Table 6-5. Summary of 10-year WSELs and Velocities within the Tijuana River

HEC-RAS Cross-Section (1)	Description	10-year Water Surface Elevation (ft)				Average Total Velocity (feet per second)			
		Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4
41.3		8.0	8.1	8.1	7.7	1.6	1.6	1.6	1.7
56.8		9.0	9.0	9.0	8.7	2.5	2.4	2.4	2.3
77.5	D/S end of AmSod berm	12.2	12.2	12.2	12.1	2.6	2.6	2.6	2.5
97.7		14.4	14.4	14.3	14.3	2.7	2.7	2.5	2.6
120.1	Saturn Boulevard	18.4	18.5	18.5	18.5	6.3	6.3	6.1	6.1
134.9	U/S end of AmSod berm	22.4	22.4	22.0	22.0	2.8	2.8	3.3	3.3
147.1	Hollister Street	23.7	23.7	23.3	23.3	4.8	4.7	4.4	4.4
155.7		24.3	23.9	23.7	23.7	7.6	9.0	9.6	9.6
179.2		26.7	26.5	26.5	26.5	1.7	1.8	1.8	1.8
206.3	Dairy Mart Road	30.5	30.3	30.3	30.3	2.3	1.6	1.6	1.6
229.7		38.6	38.6	38.6	38.6	4.0	4.0	4.0	4.0
242.6		40.5	40.5	40.5	40.5	3.5	3.5	3.5	3.5

D/S -Downstream
U/S -Upstream
(1) Not all cross-sections from the HEC-RAS models are included within the table above. The cross-sections within the table have been selected as key locations along the Tijuana River Valley. To view all of the cross-sections within the model, please refer to the comprehensive summary table and HEC-RAS workmap located in Appendices 2 through 6.

Table 6-6. Summary of 100-year WSELs and Velocities within the Tijuana River

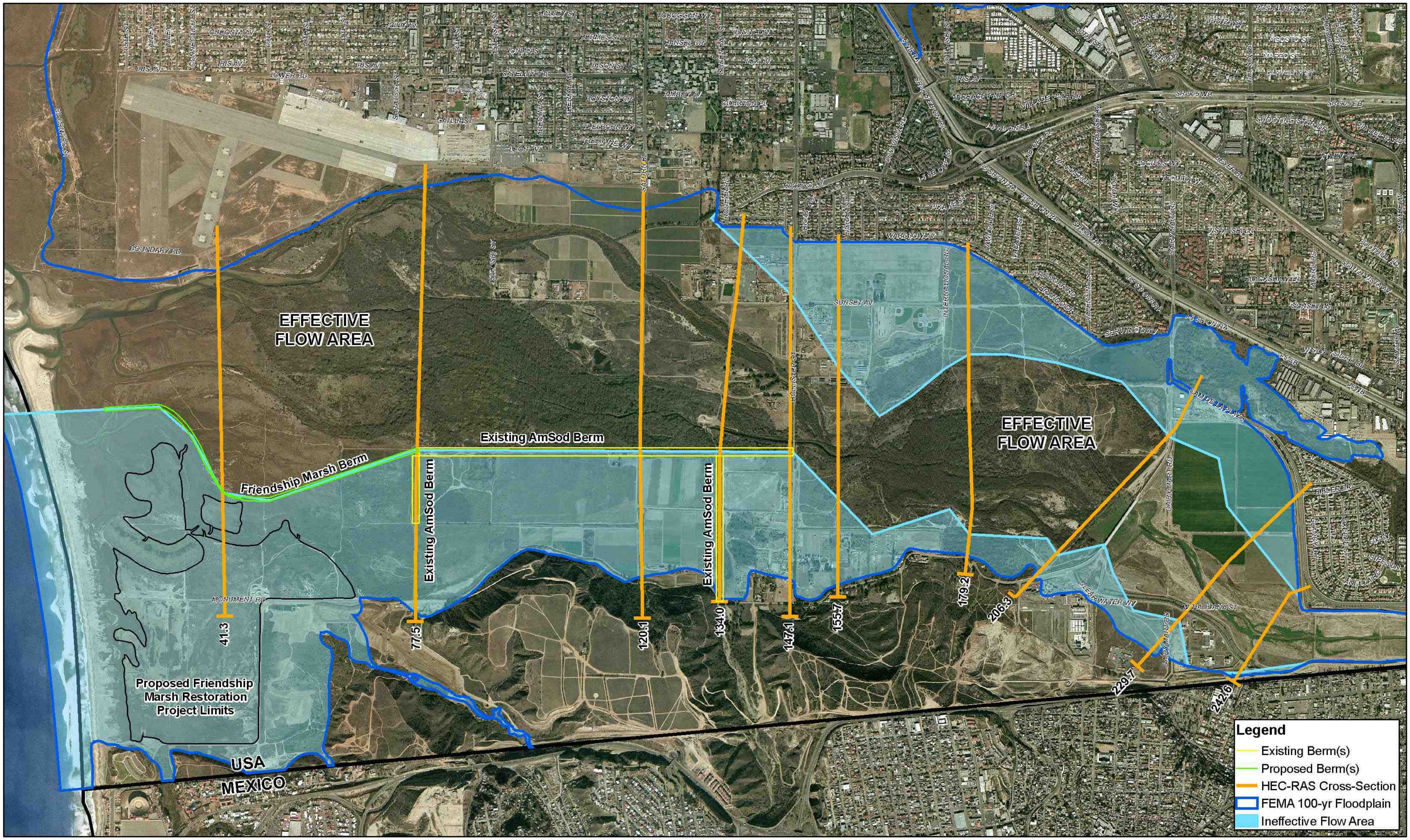
HEC-RAS Cross-Section (1)	Description	100-year Water Surface Elevation (ft)				Average Total Velocity (feet per second)			
		Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4
41.3		14.7	14.6	14.6	14.5	2.1	2.0	2.0	2.0
56.8		14.9	14.9	14.9	14.7	2.3	2.3	2.3	1.9
77.5	D/S end of AmSod berm	16.0	16.0	16.0	15.4	3.2	3.2	3.2	2.6
97.7		18.2	18.2	17.9	17.5	3.5	3.5	2.9	3.2
120.1	Saturn Boulevard	21.5	21.5	21.0	21.0	5.7	5.7	6.1	6.1
134.9	U/S end of AmSod berm	25.2	25.1	24.6	24.6	5.0	4.7	4.8	4.8
147.1	Hollister Street	27.5	27.1	26.6	26.6	7.0	5.6	4.5	4.5
155.7		29.9	29.6	28.6	28.6	6.2	3.7	3.7	3.7
179.2		32.2	31.1	30.6	30.6	3.0	3.3	3.6	3.6
206.3	Dairy Mart Road	35.5	35.0	35.0	35.0	4.5	3.3	3.3	3.3
229.7		43.1	43.1	43.1	43.1	6.8	6.0	6.0	6.0
242.6		45.9	45.7	45.7	45.7	5.9	5.8	5.8	5.8

D/S -Downstream
U/S -Upstream
(1) Not all cross-sections from the HEC-RAS models are included within the table above. The cross-sections within the table have been selected as key locations along the Tijuana River Valley. To view all of the cross-sections within the model, please refer to the comprehensive summary table and HEC-RAS workmap located in Appendices 2 through 6.

All of the models were based on river geometry modeled from the FLUVIAL-12 analysis prepared by Dr. Chang (2004), with modifications to reflect each preliminary design alternative. The proposed Friendship Marsh Berm configuration was incorporated into all of the models. Both the 10-year 100-year flood analyses were conducted within the hydraulic models for reference; however, the emphasis of this report is the 100-year flood event. The preliminary WSELs and average velocities for both the 10-year and 100-year storm events can be found in Table 6.5 and Table 6.6, respectively.

Alternative 1: No-Action Alternative - *Existing Berm Condition with Friendship Marsh Berm*

The results of the HEC-RAS model for the No Action Alternative are depicted in Figure 6-13. This model is based on the existing condition geometry from the FLUVIAL-12 model including the existing berms within the Tijuana River Valley, the AmSod berm(s), and the proposed Friendship Marsh Berm. The area of ineffective flow is shaded blue. Locations of ineffective flow occur upstream and downstream of constrictions, and occur in areas impacted by the existence of earthen berms. In terms of effective and ineffective flow at the downstream end of the river, the results of this model compare well with the results of Dr. Chang's model of the Friendship Marsh Berm and AmSod berm presented previously. Thus, the 100-year WSELs computed with this model will serve as a baseline for comparison to determine the impact of the potential AmSod berm alternative configurations.



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Alternative 1 : No Action Alternative
Existing Berm Condition with Friendship Marsh Berm

FIGURE 6-13

Alternative 2: (Preferred Alternative) - ***Protected AmSod Condition with Friendship Marsh Berm***

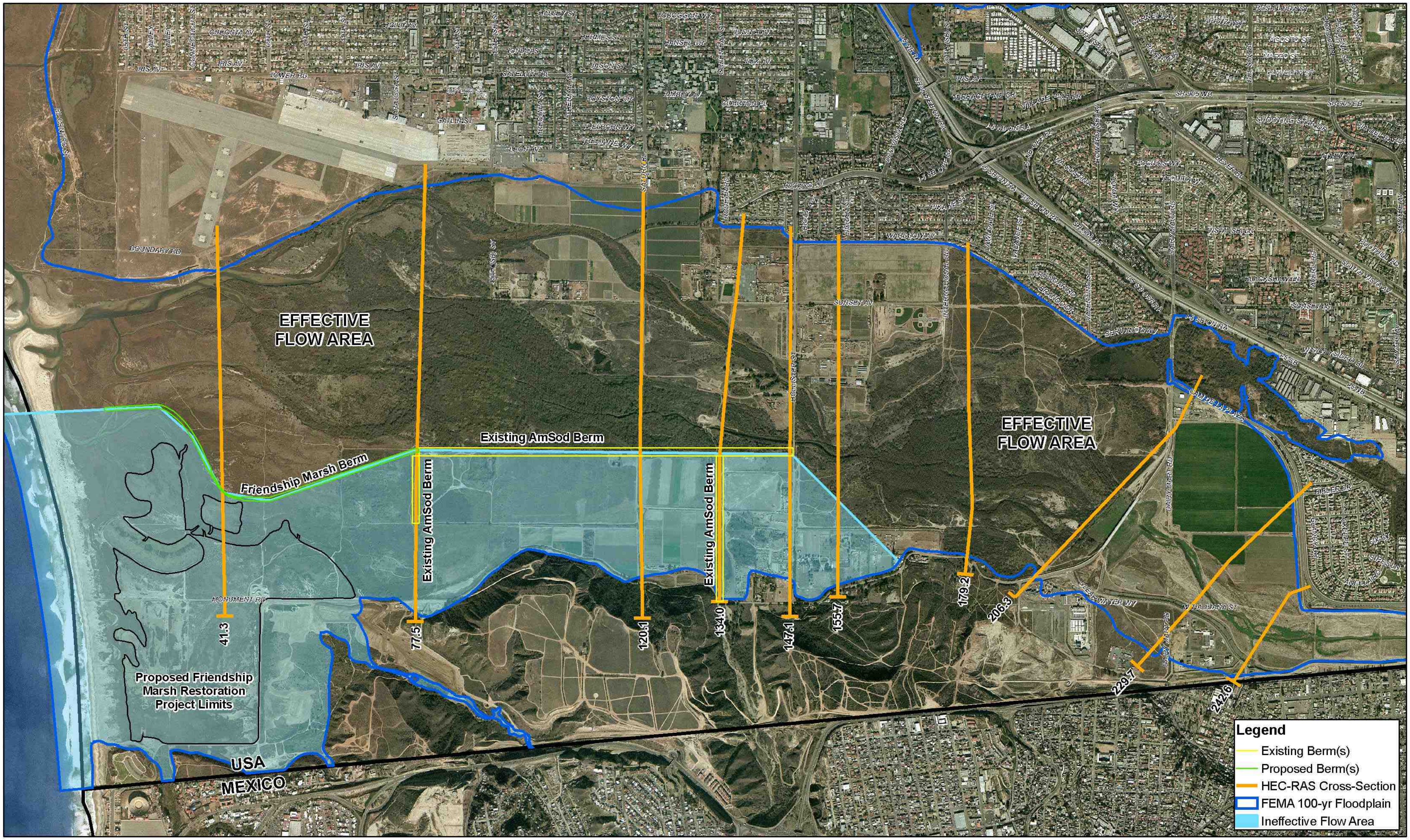
The Preferred Alternative model is based on the assumption that all of the existing berms, with the exception of the AmSod berm(s), within the Tijuana River Valley have been removed. This model includes the proposed Friendship Marsh Berm. The HEC-RAS analyses include the associated ineffective flow areas for the AmSod and Friendship Marsh berms. The results of this model are depicted in Figure 6-14.

The removal of the existing berms within the Tijuana River Valley will increase the conveyance area, resulting in a general reduction of WSELs within the floodplain, when compared to the existing condition (no-action alternative). In the Alternative 2 (Protected AmSod Condition with Friendship Marsh Berm) model, the Friendship Marsh Restoration Project is located within an ineffective flow area created by the AmSod berm(s) and the proposed Friendship Marsh Berm. As a result, the Friendship Marsh Restoration Project would be protected from inflows of sediment and debris transported by the Tijuana River.

Alternative 3: ***Alternative AmSod Condition with Friendship Marsh Berm***

The Alternative AmSod Condition with Friendship Marsh Berm model assumes that all of the existing berms within the Tijuana River Valley have been removed, including removal of a portion of the AmSod berm, and includes the proposed Friendship Marsh Berm. Currently, the downstream and upstream edge of the AmSod property is protected by existing earthen berms oriented in a north/south direction. The northern edge of the AmSod property is protected by an existing earthen berm oriented in a west/east direction. The portions of the AmSod berms would be removed for Alternative 3 are located at the upstream edge and northern edge of the AmSod property. The HEC-RAS analyses include the associated ineffective flow areas for the remaining western portion of the AmSod berm and the proposed Friendship Marsh Berm as depicted in Figure 6-15.

The removal of the northern and upstream AmSod berms will have negligible effects on WSELs downstream of the AmSod property, when compared to the existing condition (no-action alternative). In Alternative 3, the portion of the AmSod berm at the downstream side of the AmSod property would remain to aid in protecting the Friendship Marsh Restoration Project against sediment inflow and debris transported by the Tijuana River. The presence of this berm would maintain an ineffective flow area immediately upstream and would prevent the inflow of sediment and debris. The Friendship Marsh Berm proposed in the Friendship Marsh Restoration Project would connect to the downstream edge of the existing AmSod berm.



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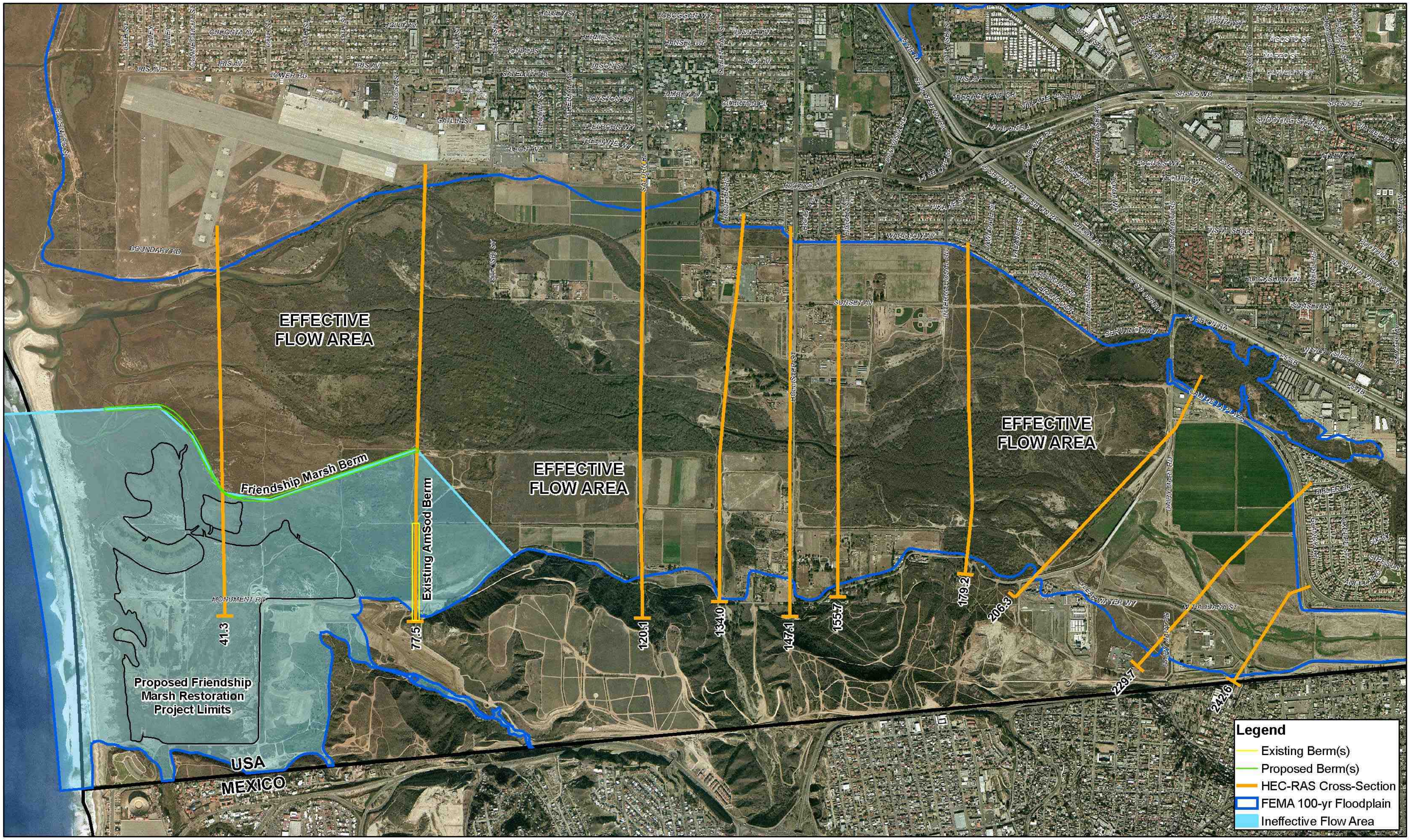
Alternative 2 (Preferred Alternative)
Protected AmSod Condition with Friendship Marsh Berm

FIGURE 6-14



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Alternative 3
AmSod Berm Alternative Condition with Friendship Marsh Berm

FIGURE 6-15

Alternative 4: ***Existing Berms Removed Condition with Friendship Marsh Berm***

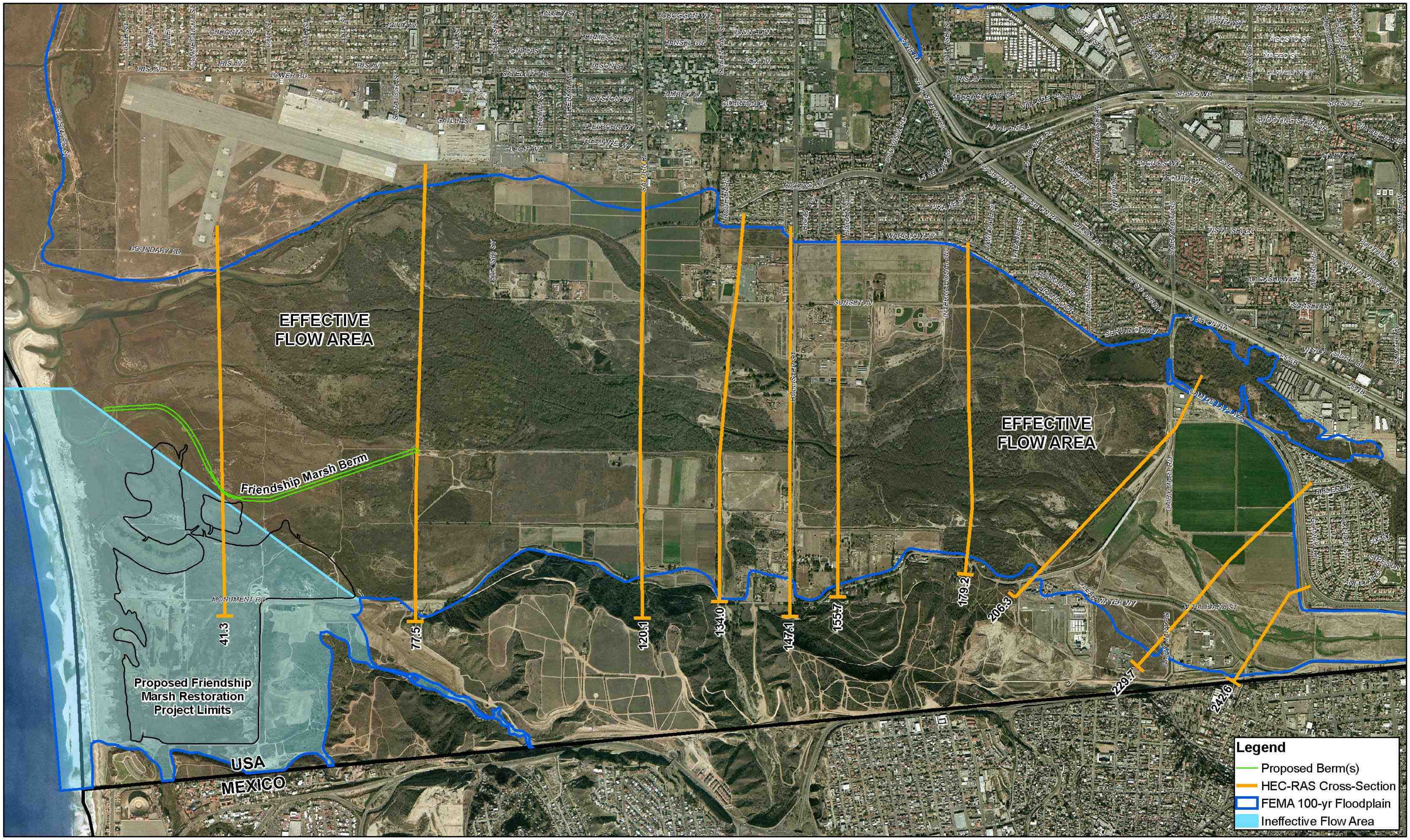
Previous studies prepared by various stakeholders within the Tijuana River Valley have recommended that the existing berms within the valley, including the AmSod berm, be removed to restore the floodplain to a more natural drainage condition and reduce the flooding potential to adjacent property owners. Therefore, in the Alternative 4 model, the HEC-RAS cross-sections are extended and the ineffective flow areas, created by the existing berms modeled in Alternative 1, have been eliminated for a majority of the Tijuana River Valley. This scenario would allow floodwater to extend as far north and south as topography allows as illustrated in Figure 6-16.

This scenario has the largest flood-control benefit for the Tijuana River Valley. The removal of all the existing berms, including the AmSod berm(s), would increase the floodplain conveyance area resulting in the greatest reduction in WSELs within the floodplain when compared to Alternative 1.

Aside from the flood control benefits, Alternative 4 has several distinct disadvantages. Complete removal of all of the AmSod berm(s)would allow floodwater from the Tijuana River to inundate all of the AmSod property and the effective flow areas of the floodplain limits would extend south to Monument Road. This would allow sediment-laden floodwater from the Tijuana River to flow directly into the Friendship Marsh Restoration area. In addition to this increased inundation, the natural constriction at the mouth of the Tijuana River would create an ineffective flow area within the restoration area. This could result in large quantities of sediment deposition in the northeastern portion of the Friendship Marsh, damaging or hindering habitat restoration efforts. Riparian habitat restoration could also become more difficult to establish within the AmSod property without the protection from sediment and debris inflow currently provided by the berms within the property limits.

To summarize, the existing AmSod berm in its current configuration acts as a barrier, protecting the area proposed for the Friendship Marsh Restoration Project from damage due to high flood flows, sedimentation, and debris. In addition, the AmSod berm also provides a connection point for the proposed Friendship Marsh Berm that also functions as a protective barrier from debris and sediment generated by 10-year flood events.

If the AmSod berm is removed, the Friendship Marsh Berm may need to be realigned to recreate the physical barrier against sediment and debris inflow that is currently provided by the existing AmSod Berm. A possible realignment would leave the western half of the proposed berm in its current location, and would realign and extend its eastern half to connect with Monument Road located to the south. Any berm realignment would require further hydraulic analysis to quantify the impacts to the Tijuana River Floodplain.



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Alternative 4
Existing Berms Removed Condition with Friendship Marsh Berm

FIGURE 6-16

Breaching the AmSod Berm

To meet the SDCWA goal of restoring the riparian habitat within the AmSod property while reducing the potential impacts to the Friendship Marsh Restoration Project, portions of the AmSod berm could be breached as an alternative to its complete removal. Constructing engineered drainage structures through the AmSod berm(s), or removing specific portions of the berm(s), could allow floodwater to inundate the AmSod property in a controlled manner and would aid in restoring the riparian habitat within the property. Most of the AmSod berm would remain in its current location; thus maintaining the ineffective flow characteristics within the AmSod property. The remaining AmSod berm also would protect the Friendship Marsh Restoration Project, and any SDCWA habitat restoration efforts, from sediment and debris damage during storm flows in the Tijuana River Valley. The hydraulic impacts of breaching portions of the berm on the Tijuana River floodplain would be approximately the same as Alternative 2.

One option would create a breach at the downstream (western) end of the AmSod property, immediately upstream of the connection for the Friendship Marsh Berm and AmSod berm. At this location, the floodwater would encroach into the AmSod property and pond to a WSEL lower than the existing top of berm elevation. A second option would create two (or more) breaches within the AmSod berm. An inlet breach location could be constructed towards the upstream (eastern) end of the AmSod berm. These options are discussed further in Section 6.9.2.

No Friendship Marsh Berm and Weir

During project review, it was noted that the demarcation between the effective and ineffective flow as determined by the FLUVIAL 12 model occurred near the northern end of the proposed restoration. It appeared as though the proposed berm and weir would provide protection only for that small restored area to the northeast of the effective/ineffective flow boundary (Figure 6-17). Thus, it was decided that Rick Engineering Company (Rick) should conduct additional hydraulic analyses to illustrate the effects of sedimentation and scour on the preferred restoration site without the proposed berm and weir. The results of this analysis are presented in Section 6.10. The complete hydraulic analysis as compiled by Rick is provided in Appendices F and G.

Review of hydraulic calculations of flow velocities and shear forces occurring in the ineffective flow area indicated that during flood events the Tijuana River has the force to transport sediment as large as 5 mm in diameter (small gravel) along the ineffective flow boundary. Sediment analysis conducted by AMEC Earth and Environmental (Section 8.0 Substrate Characterization) determined that during flood events the shear forces of river flows and sediment transport capabilities would allow transport of the majority of the existing Tijuana River bed. Together these data suggest that during flood events the channel bed would be highly mobile as flows approach the ineffective flow boundary. Once this sediment-laden water crosses into the ineffective flow area, characteristic decreased velocities would result in sediment deposition within the restored wetland. Thus, it is the opinion of Rick Engineering that the proposed berm and weir are necessary to prevent sediment transport and deposition in the restored wetland.

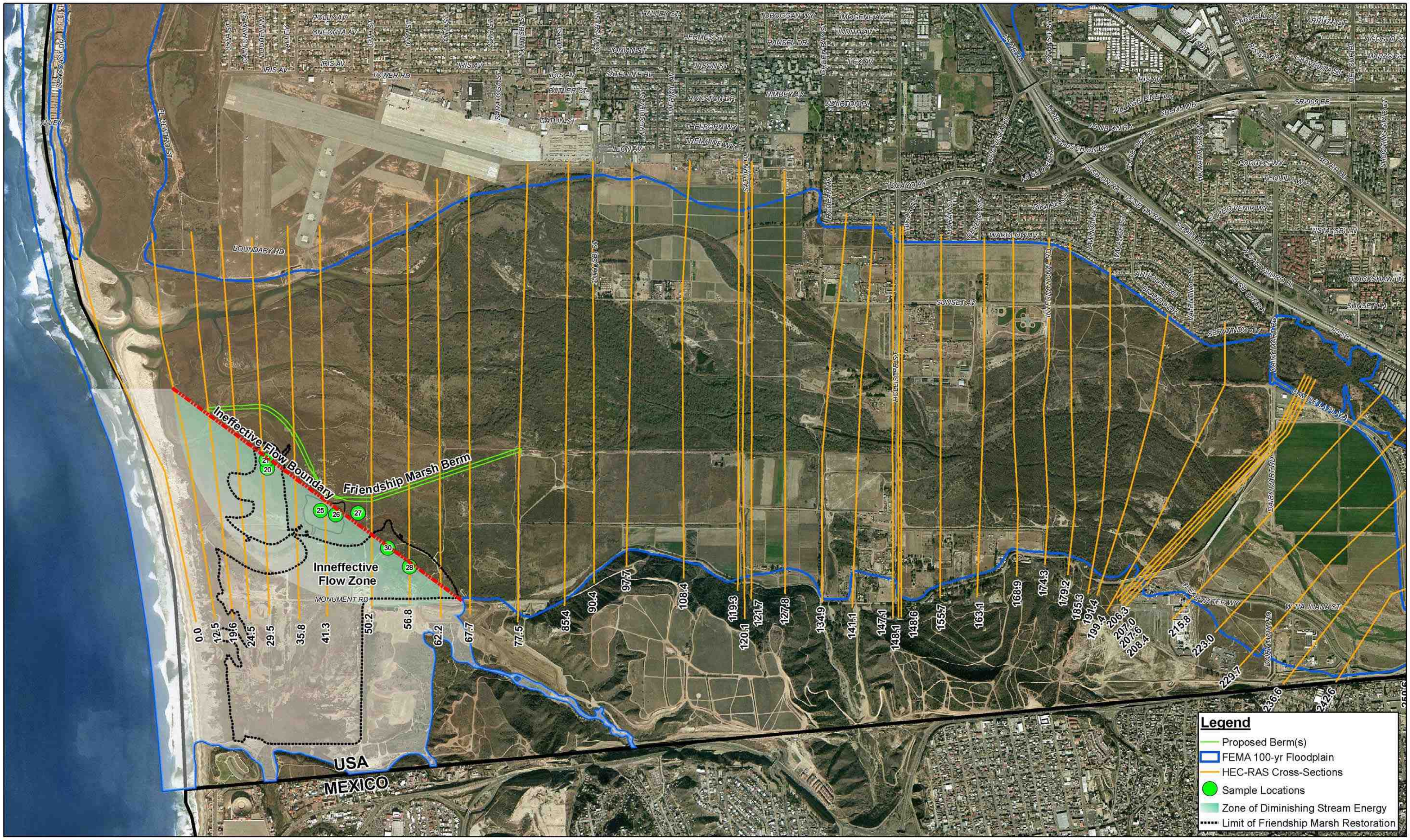

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FIGURE 6-17
Hydraulic Analysis of Project Without Proposed Berm and Weir

SECTION 7.0 BIOLOGICAL RESOURCES

The biological resources of Tijuana Estuary have been the focus of numerous studies culminating in a summary of the aquatic and terrestrial habitats presented in *The Ecology of Tijuana Estuary: An Estuarine Profile* (Zedler and Nordby 1986) and its update *The Ecology of Tijuana Estuary: A National Estuarine Research Reserve* (Zedler et al. 1992). Much of the data presented in these publications was collected from studies in the northern arm of the estuary. The current project area, located in the southern arm of the estuary, has received less attention, primarily a result of its degraded state. During the initial phases of this project, it was determined that updated surveys of vegetation and selected wildlife species would be required in order to adequately address potential project benefits and impacts. Accordingly, focused surveys of flora and fauna were conducted in the southern arm in 2004 and 2005. The 2004 survey area encompassed an area of approximately 600 acres while surveys in 2005 focused on the approximately 260-acre Preferred Project Area.

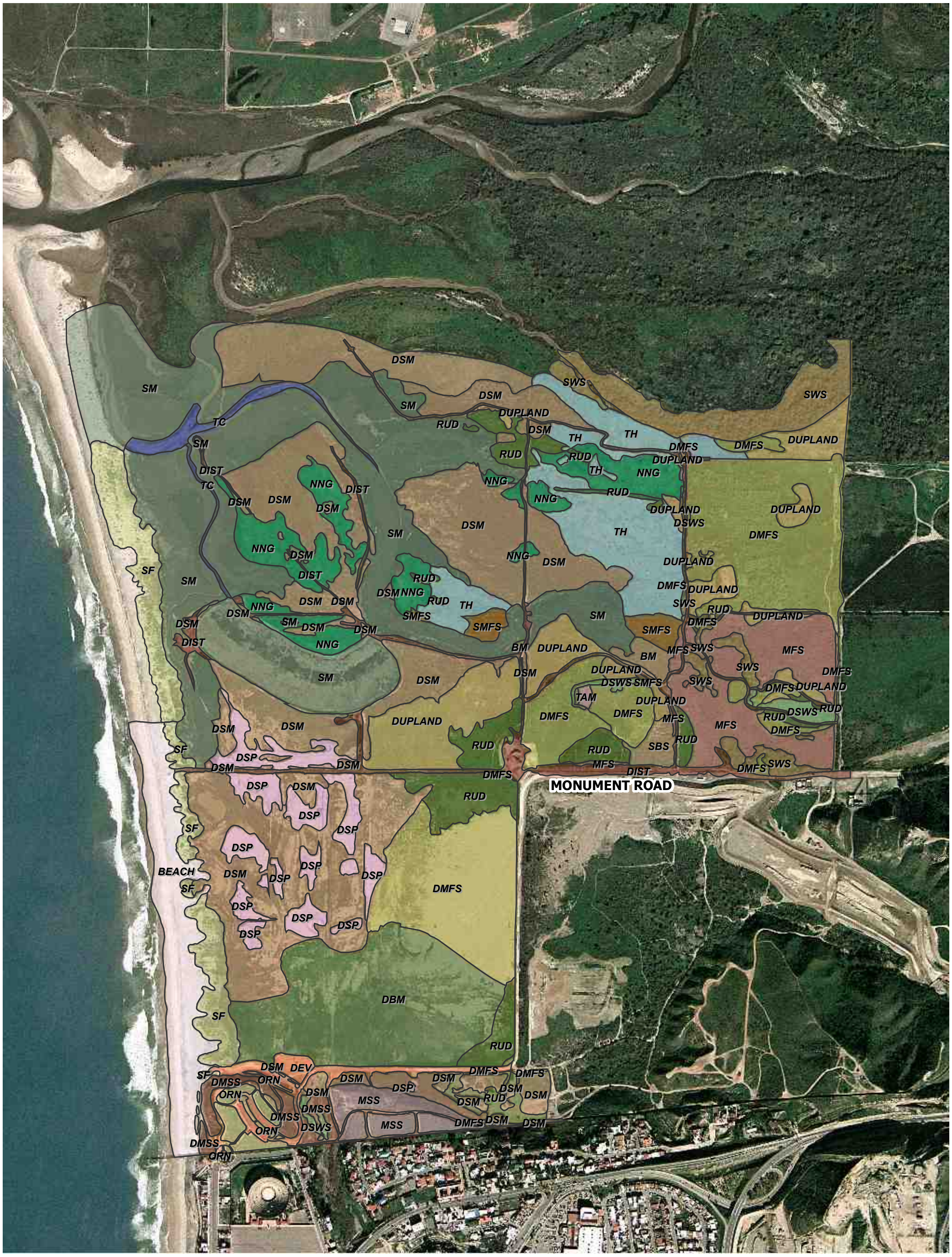
Vegetation Communities

The composition of vegetation communities in the Tijuana River Valley has been influenced by numerous factors, including freshwater input, sedimentation, and disturbance from border patrol, military and agricultural uses. The project area also has been negatively affected by increased residential development in Tijuana that has resulted in unstable bluffs and, consequently, increased sediment deposition in the river valley. Over time, this sedimentation has raised the elevation of the marsh plain in the project area. Higher elevations combined with freshwater flows have facilitated colonization by exotic plant species in many areas that once supported only salt marsh plant species.

In addition to changes in the physical environment over time, vegetation in the project area has been directly impacted by border patrol, military and agricultural activities that have resulted in damage to native vegetation communities and the introduction, and increased proportion, of non-native species. A summary of recent changes in the project area is presented in Section 2.4 History of Disturbance.

Although it has been subject to much disturbance in the recent past, Tijuana Estuary supports a diversity of native vegetation communities and wildlife. Vegetation observed in the project area includes saltwater and freshwater marsh communities as well as those typical of more xeric habitats. Many of these communities have been greatly reduced in southern California. As a result, many of the plant and wildlife species that rely on them for survival are now threatened with extinction. Coastal salt marsh associated with Tijuana Estuary is considered to be particularly valuable as approximately 91 percent of coastal wetlands in the state of California have been lost to development (California Department of Fish and Game, 2001).

The 2005 distribution of the vegetation communities observed in the extended project area is illustrated in Figure 7-1. This 2005 condition is compared to the 2004 vegetation communities that existed prior to sediment deposition in January 2005 (Figure 7-2). A comparison of the



- SF/Southern Foredunes
- SM/Southern Coastal Salt Marsh
- DSM/Disturbed Southern Coastal Salt Marsh
- DSP/Disturbed Salt Panne
- MFS/Mule-fat Scrub
- DMFS/Disturbed Mule-fat Scrub
- BM/Coastal Brackish Marsh
- DBM/Disturbed Brackish Marsh
- SWS/Southern Willow Scrub
- DSWS/Disturbed Southern Willow Scrub
- DFWM/Disturbed Coastal Freshwater Marsh
- MSS/Maritime Succulent Scrub
- DMSS/Disturbed Maritime Succulent Scrub
- TH/Transitional Habitat
- SBS/Saltbush Scrub
- SMFS/Salt Marsh Fleabane Scrub
- NNG/Non-Native Grassland
- TAM/Tamarisk Scrub
- DUPLAND/Disturbed Upland Habitat
- RUD/Ruderal
- ORN/Ornamental
- DIST/Disturbed
- DEV/Developed
- TC/Tidal Channel
- BEACH/Beach

RICK ENGINEERING COMPANY

TIJUANA ESTUARY 2005

1 inch equals 800 feet

0 400 800 Feet

FIGURE 7-1 Vegetation Communities of the Project Survey Area, 2005

- SF/Southern Foredunes
- SM/Southern Coastal Salt Marsh
- DSM/Disturbed Southern Coastal Salt Marsh
- SP/Salt Panne
- DMFS/Disturbed Mule-fat Scrub
- SWS/Southern Willow Scrub
- DSWS/Disturbed Southern Willow Scrub
- FWM/Coastal Freshwater Marsh
- DFWM/Disturbed Coastal Freshwater Marsh
- TH/Transitional Habitat
- SBS/Saltbush Scrub
- NNG/Non Native Grassland
- TAM/Tamarisk Scrub
- DUPLAND/Disturbed Upland Habitat
- ORN/Ornamental
- DEV/Developed
- DIST/Disturbed
- SMFS/ Salt Marsh Fleabane Scrub
- BEACH/Beach
- BM/Coastal Brackish Marsh
- MSS/Maritime Succulent Scrub
- DCSS/Diegan Coastal Sage Scrub
- DDCSS/Disturbed Diegan Coastal Sage Scrub
- DSF/Disturbed Southern Foredunes
- DSM/DUPL/Disturbed Southern Coastal Salt Marsh/Disturbed Upland Habitat
- DSM/SP/Disturbed Salt Marsh/Salt Panne
- MFS/Multi-fat Scrub
- RUD/Ruderal
- TC/Tidal Channel

RICK
ENGINEERING COMPANY

TIJUANA ESTUARY
2004

1 inch equals 800 feet

0 400 800 Feet

FIGURE 7-2 **Vegetation Communities of the Project Survey Area, 2004**

two vegetation maps demonstrates the damage resulting from this event. The greatest impact to Tijuana Estuary was observed within the area west of Monument Road and south of the beach access horse trail. Post-storm effects observed included the conversion of disturbed salt marsh habitat to disturbed mule-fat scrub and the conversion of disturbed southern coastal salt marsh and salt panne to disturbed brackish marsh.

Within each habitat type, the proportion of native and exotic plant species varies greatly, from relatively undisturbed native communities to habitats that support monotypic stands of exotic species. However, nearly all of the habitats described in this document are either dominated by or support some non-native species, a situation compounded by fresh water inflows and sediment deposition.

Wildlife

Faunal resources of the project area were historically both diverse and abundant. However, years of habitat degradation have had a negative effect.

Numerous surveys have been conducted for aquatic and terrestrial wildlife species in the project vicinity; however, few have focused on the south arm of the estuary. Focused surveys of the south arm were conducted in support of the Tijuana Estuary Tidal Restoration Program EIR/EIS (Entrix et al. 1991). Additional focused surveys were conducted in support of this feasibility and design study. These are summarized below.

Sensitive Species

Appropriate habitat for Belding's savannah sparrow (*Passerculus sandwichensis beldingi*) occurs throughout much of the project area. Therefore, it was determined that focused surveys for this species were necessary. Focused surveys were conducted in the spring of 2004. The purpose of these surveys was to determine the distribution of Belding's savannah sparrow within what was then defined as the proposed project area.

As presented previously, heavy rainfall during January of 2005 resulted in the deposition of large amounts of sediment within the area located south of the horse trail and bound by Monument Road. Consequently, areas that once supported disturbed coastal salt marsh habitat were converted to disturbed mule-fat scrub or were devoid of vegetation. Additional focused surveys of Belding savannah sparrow were conducted in 2005 to assess the effects of loss of disturbed coastal salt marsh habitat on this species.

Approximately 40% of disturbed salt marsh habitat occurring within the southeastern survey area was destroyed by sediment during this deposition event. An additional 30% of this habitat was converted to disturbed brackish marsh. Therefore, approximately 70% of disturbed salt marsh habitat observed in the southeastern survey area was lost as a result of the storm and continued freshwater inflow. It was determined that approximately 70% of the pairs of sparrows observed during the 2004 surveys were displaced by sedimentation caused by the storm in 2005. The loss of pairs of sparrows appears to be evenly correlated to the loss of 70% of salt marsh habitat occurring within the southeastern area.

During construction of the proposed project, Belding's savannah sparrow may be impacted, with sparrows utilizing disturbed salt marsh habitat within the Preferred Project Area displaced. However, the project will be constructed in phases that will potentially leave habitat for displaced individuals. Once completed, the project is expected provide high quality habitat for 198-214 pairs of Belding's savannah sparrows.

Proposed Project Impacts

Construction of the Preferred Alternative would result in impacts to approximately 259.13 acres and would affect 17 habitat types. Proposed project impacts and habitat creation are presented in Table 7-6 and illustrated on Figure 7-7. As previously presented, vegetation communities occurring within the project area have been subject to continual disturbance and, as a result, are degraded. Based on studies conducted over the past several years, the loss of wetland habitat has been documented within the project area. It is not anticipated that the area will restore itself naturally. Instead, it is expected that the area will continue to deteriorate and that the biological diversity associated with Tijuana Estuary will be lost. Therefore, although the construction of the proposed project will result in impacts to existing habitats that, by name, are considered sensitive by the resource agencies, once completed, the area will support higher quality habitat and increased populations of sensitive plant and animal species.

Table 7-6. Anticipated Project Impacts and Proposed Conditions

Impacts to Existing Conditions (Acres)				Proposed Conditions	
	Project Component				
Habitat Type	***Basin**	**Berm**	**Total**	**Habitat Type**	**Acres**
Salt marsh fleabane scrub	0.56	0	0.56	Low-marsh	60.03
Brackish marsh	0.01	0	0.01	Mid-high marsh	61.32
Disturbed brackish marsh	45.44	0	45.44	Mudflat	60.66
Disturbed mule-fat scrub	44.75	2.09	46.84	Sub-tidal	61.15
Mule-fat scrub	1.84	0	1.84	Transition	7.11
Tidal channel	0.02	0	0.02		
Disturbed southern willow scrub	0.89	0.03	0.92		
Southern coastal salt marsh	2.37	2.17	4.54		
Disturbed southern coastal salt marsh	58.99	2.99	61.98		
Disturbed salt panne	20.43	0	20.43		
Transitional habitat	4.16	1.37	5.52		
Disturbed upland	22.41	0.11	22.52		
Non-native grassland	17.08	0.04	17.12		
Saltbush scrub	2.73	0	2.73		
Ruderal	20.15	0	20.15		
Tamarisk	0.45	0	0.45		
Disturbed	7.93	0.06	7.99		
Developed	0.06	0	0.06		
Total	**250.27**	**8.86**	**259.13**	**Total**	**250.27**

* Basin refers to all sub-tidal, tidal, mudflat, low-marsh, mid-high marsh and transitional habitats; approximately 250 acres

FIGURE 7-7 Vegetation Communities Occuring within the Project Footprint, 2005

Typically, the resource agencies seek to protect remnant wetland resources. However, as it has been stressed throughout this document, those remnant wetland resources have been degraded and continue to be degraded by sediment deposition and colonization by non-native plant species. Without active restoration and habitat management, these resources will continue to deteriorate and will be replaced by weedy, upland sites with little value compared to healthy tidal wetland systems. The project will be phased so that each constructed component is functioning as wetland before proceeding to the next phase.

Phase 1 of the project is proposed for the area that was impacted by sedimentation in January 2005. It has been documented that this area was formerly salt marsh/salt panne and is now highly disturbed mule-fat scrub. It has also been presented that this site was formerly, but not currently, occupied by Belding's savannah sparrow. Therefore, the first phase of the overall restoration will entail constructing inter-tidal wetlands, open water and mudflat that will provide habitat to a suite of wetland species, including Belding's savannah sparrows. Thus, the first phase of this restoration project is considered self-mitigating. The habitat created in the first phase together with that created at the 20-acre Model Marsh, will provide habitat to fauna displaced during the construction of Phase 2. For details on construction phasing, see Section 12.0 Project Phasing and Construction Alternatives Analysis.

SECTION 8.0 SUBSTRATE CHARACTERIZATION

A major component of the Tijuana Estuary-Friendship Marsh Restoration Feasibility and Design Study is the determination of the current physical and chemical characteristics of the soils and sediments to be excavated. The characteristics of the material to be removed will determine where it can be disposed of and by what methods. One of the goals of this program is to maximize the beneficial reuse of excavated materials for beach and dune restoration.

The majority of the project area falls under U. S. Army Corps of Engineers (USACE) jurisdiction according to Section 404 of the Clean Water Act. The USACE and U. S. Environmental Protection Agency (EPA) have established procedures for evaluating the suitability of soil and sediments for various disposal alternatives. The guidance document, titled *Evaluation of Dredged Material Proposed for Disposal for Discharge in the Waters of the U.S. – Testing Manual* (referred to as the "Inland Testing Manual"), provides a set of tiered approaches to evaluate the most appropriate inland, beach, or nearshore disposal options (EPA/USACE 1998). If ocean disposal is proposed, sediment testing would be conducted according to the Green Book (EPA/USACE 1991). These sediment evaluation studies are required in order to obtain a disposal permit from the USACE. Permitting is done in conjunction with the EPA and other federal and state agencies. In addition to federal testing requirements, the San Diego Regional Water Quality Control Board (RWQCB) has established waiver criteria in the San Diego Basin Plan for industrial or commercial reuse of dredged material (RWQCB 1998).

For the purposes of this feasibility and design study, sediment was tested to assess:

- Potential chemical contamination of the sediment in the study footprint;
- The grain size and other important physical characteristics of the material;
- The ability of the excavated sediment to support plant life; and.

- The likelihood that significant cultural resources occur in the study area.

The results of this sediment characterization study will be used to identify and permit the most appropriate sediment disposal options, focusing on maximizing the beneficial reuse of excavated or dredged material.

Beneficial Use/Disposal Options

The Clean Water Act mandates that excavated or dredged soils and sediment be assessed for beneficial reuse to the maximum extent practical. A number of beneficial reuse alternatives exist for the material to be excavated as part of this study. These beneficial reuses consist primarily of beach nourishment, nearshore placement for littoral cell replenishment, berm construction within the current project footprint, dune enhancement, and upland contouring and structural fill uses. Other non-beneficial reuse disposal options include placement at the LA-5 ocean disposal site, placement in an overdredged sand pit within the estuary area, disposal at an inactive sand/gravel quarry, and disposal at a municipal landfill.

If the material is sandy enough, beach nourishment is the preferred option. The USACE's rule of thumb for beach nourishment suitability is that the material should have 80% of the sediment greater than 0.075 mm in size, and be compatible with the grain size, texture, and color of the sand at the proposed receiver beach. However, these specifications are guidelines and for this study, all sediments greater than 0.063 mm in size are considered acceptable sands. Finer grained material not suitable for beach nourishment could be used for dike/berm creation, or to fill in over-dredged areas to bring them to grade. The reuse alternatives are dictated by two factors; 1) the physical properties of the material (e.g., grain size distribution) and 2) the level of chemical contaminants present. The options for disposal of excavated sediments are examined in detail in Section 11. Material Disposal Options.

Sediment Collection Locations

The project was divided into three separate test sites based on past land use patterns and previous studies (Figure 8-1). The easternmost site (Site 1) is an area that has historically been used for agriculture; therefore, some detectable levels of pesticides may be present. Very little information is available regarding the sediment quality and past usage at the northernmost site (Site 2). The southernmost site (Site 3) is in the vicinity of the Model Marsh, where sediment chemistry and grain size data are available from previous studies. In addition, Site 3 contains the area that is most affected by sedimentation and runoff from Goat Canyon. The number of core samples collected from each test site is listed below:

- Site 1 - 7 core samples
- Site 2 - 5 core samples
- Site 3 - 12 core samples

One core sample was collected at each of the 24 locations. In addition to soil borings, sediment samples were collected from the river channel at six locations to assist in hydrologic modeling (Figure 8-1). Collections for hydrologic modeling consisted of two-foot-deep core samples.

Each was composited and analyzed for grain size only. All samples were collected between January 21 and February 2, 2004.

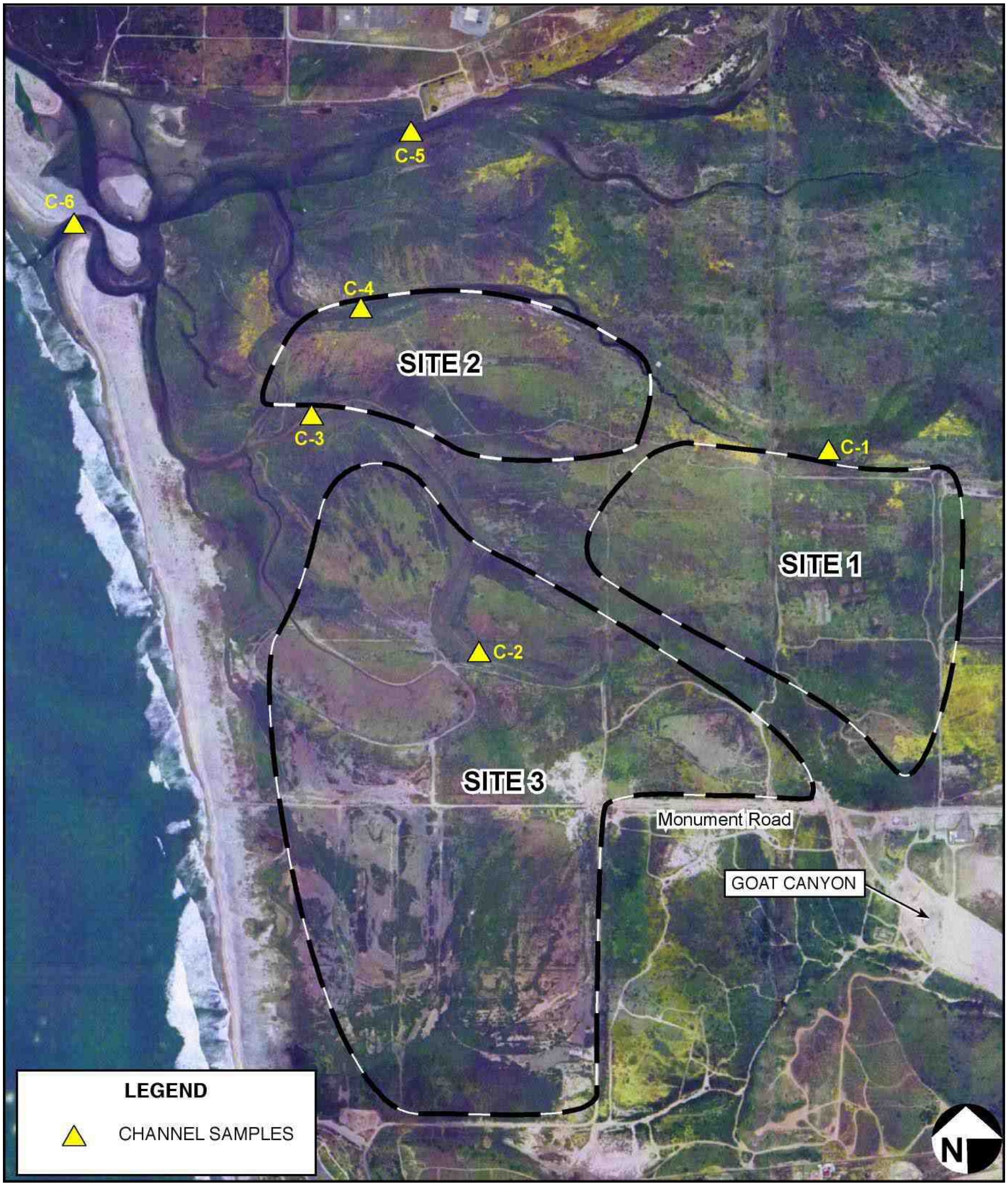


Figure 8-1. AMEC soil sampling plan

Grain Size Analyses

Grain size analyses were performed on individual strata following the EPA/USACE-approved sieve and hydrometer method (ASTM 1967).

Chemical Analyses

Because the current study is a feasibility study, chemical analyses were conducted on a limited number of samples (n = 6). However, analyses were conducted on those samples that were determined to have the greatest potential for having detectable levels of contaminants. These included samples with a high percentage of fines in the upper surface layers. Samples were analyzed according to EPA/USACE-approved methods for the constituents.

Results

Grain Size

The results of the grain size analysis are summarized below and presented in Figures 8-2 through 8-4. Figures present sediment grain size distribution as probable (> 80% sand), possible (60 – 80% sand) and unlikely (< 60% sand).

Site 1. Samples for Site 1 displayed a moderate amount of stratification, with two to four strata per core. The average grain size distribution indicated that 56% of the material was sand (48% fine sand, 7% medium sand and 1% coarse sand), while 44% of the material was silt and clay. The upper strata were generally composed of silt and clay (between 36% and 74%) and varied from the surface to a depth of 4.5 feet to 19 feet below ground surface (bgs; Figure 8-2). Sandy deposits, with greater than 70% sand, were present at all sampling locations, but varied with depth. Strata with a percentage of sand greater than 80% were present at six of the seven sampling locations, but again varied by depth, with most of these deposits situated at depths greater than 10 feet (Figure 8-2).

Site 2. Samples from Site 2 displayed far fewer strata, ranging from two to three strata per location (Figure 8-3). The average grain size distribution indicated that 81% of the material was sand (67% fine sand, 13% medium sand, and 1% coarse sand), while 19% was silt and clay. Material classified as either possible or probable was found at all strata at all sampling locations with the exception of sample 2-3 (Figure 8-3) suggesting that the sediments from this area are more compatible with the nearshore receiving site.

Site 3. Site 3 displayed a moderate amount of stratification, ranging from two to five strata per sampling location. The average grain size distribution of all the samples indicated that 56% of the material was sand (48% fine sand, 7% medium sand, and 1% coarse sand), while 44% was silt and clay. Vertical distribution of suitable sands was highly variable, with a lens apparent below approximately 10 feet below ground surface (bgs) in sample locations 3-2, 3-3, 3-4, 3-6, 3-9, and 3-13; below 3 feet bgs at sample 3-1 and 3-11; and variable in other borings. These data

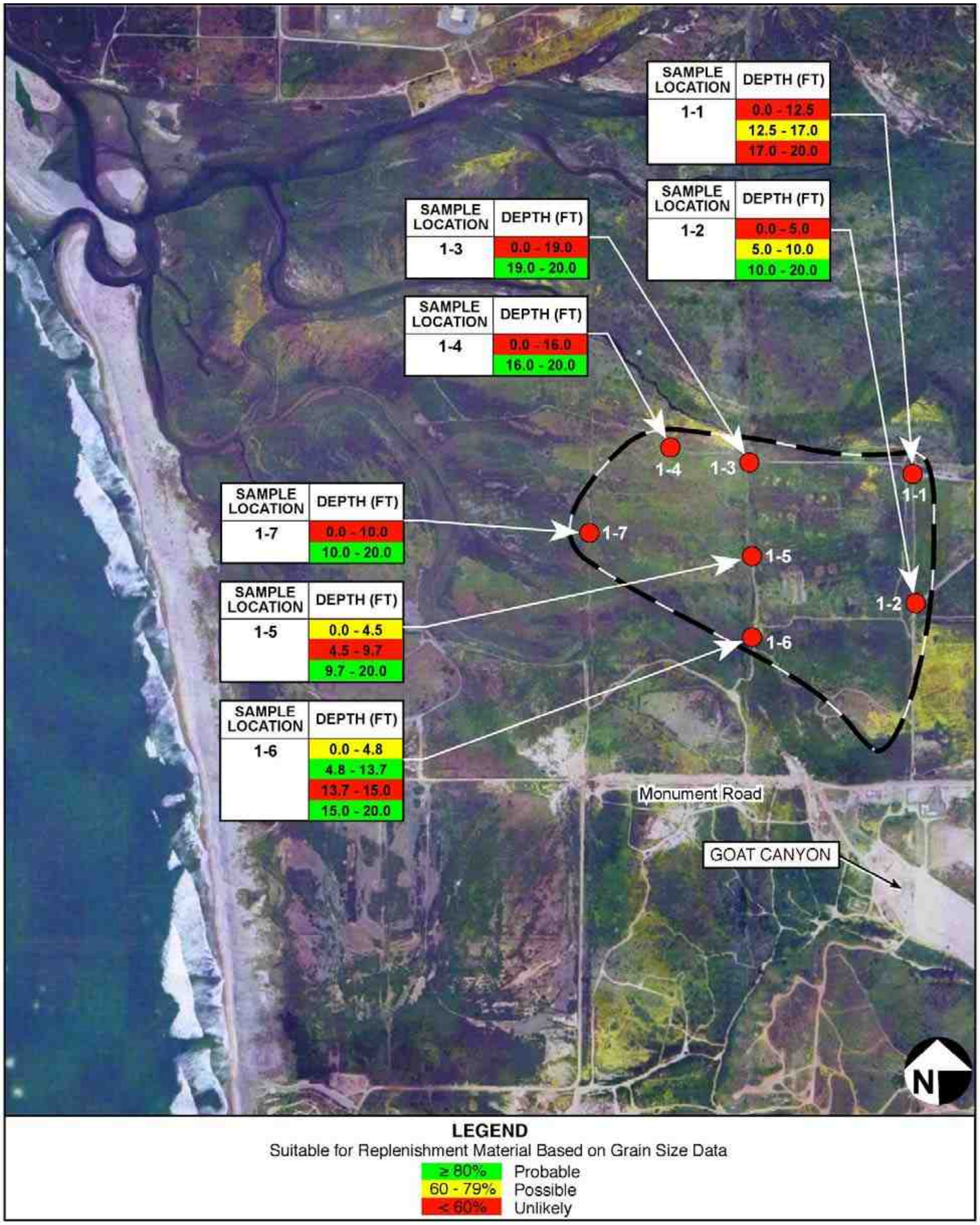


Figure 8-2. Grain Size Analysis Results for Site 1

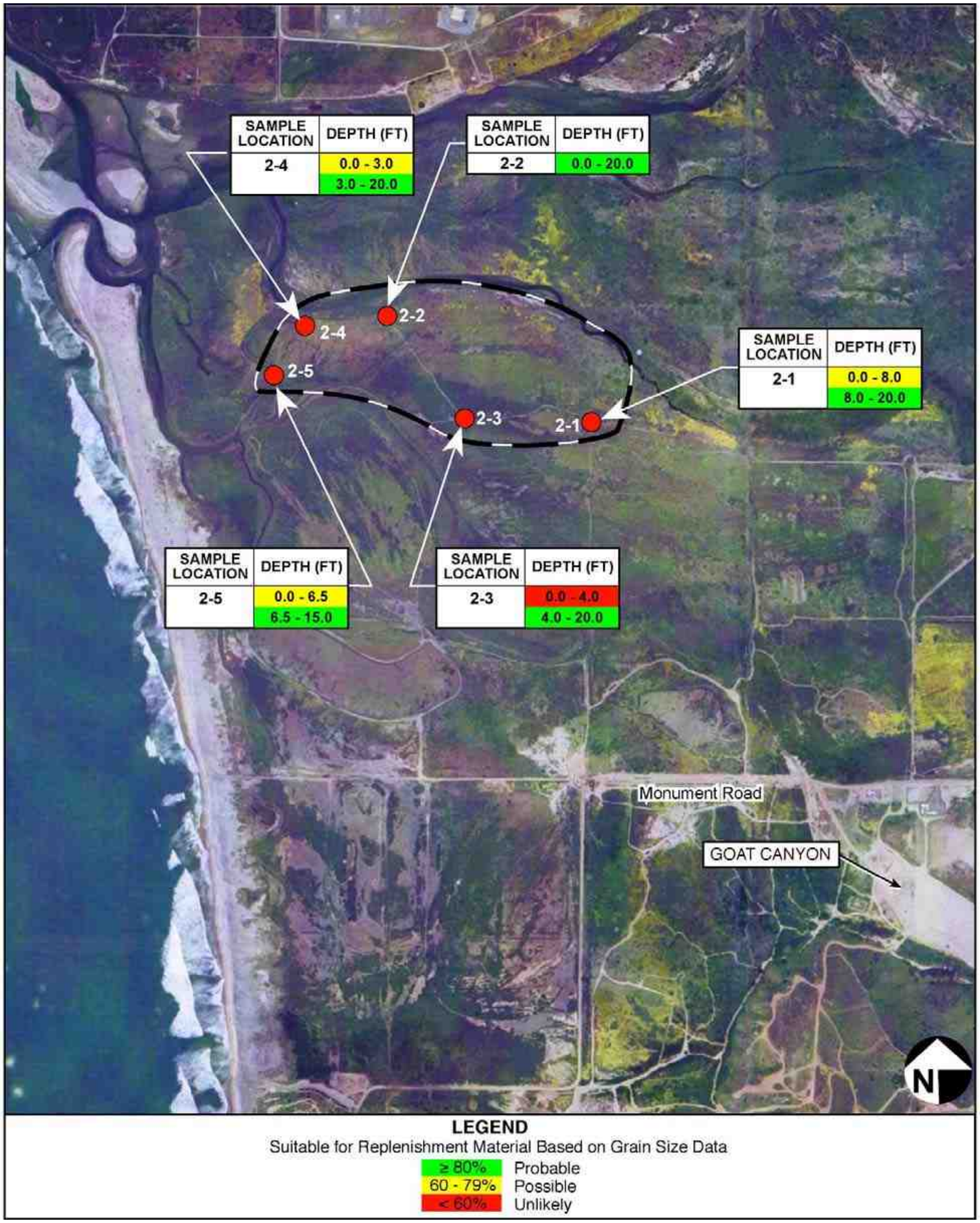


Figure 8-3. Grain Size Analysis Results for Site 2

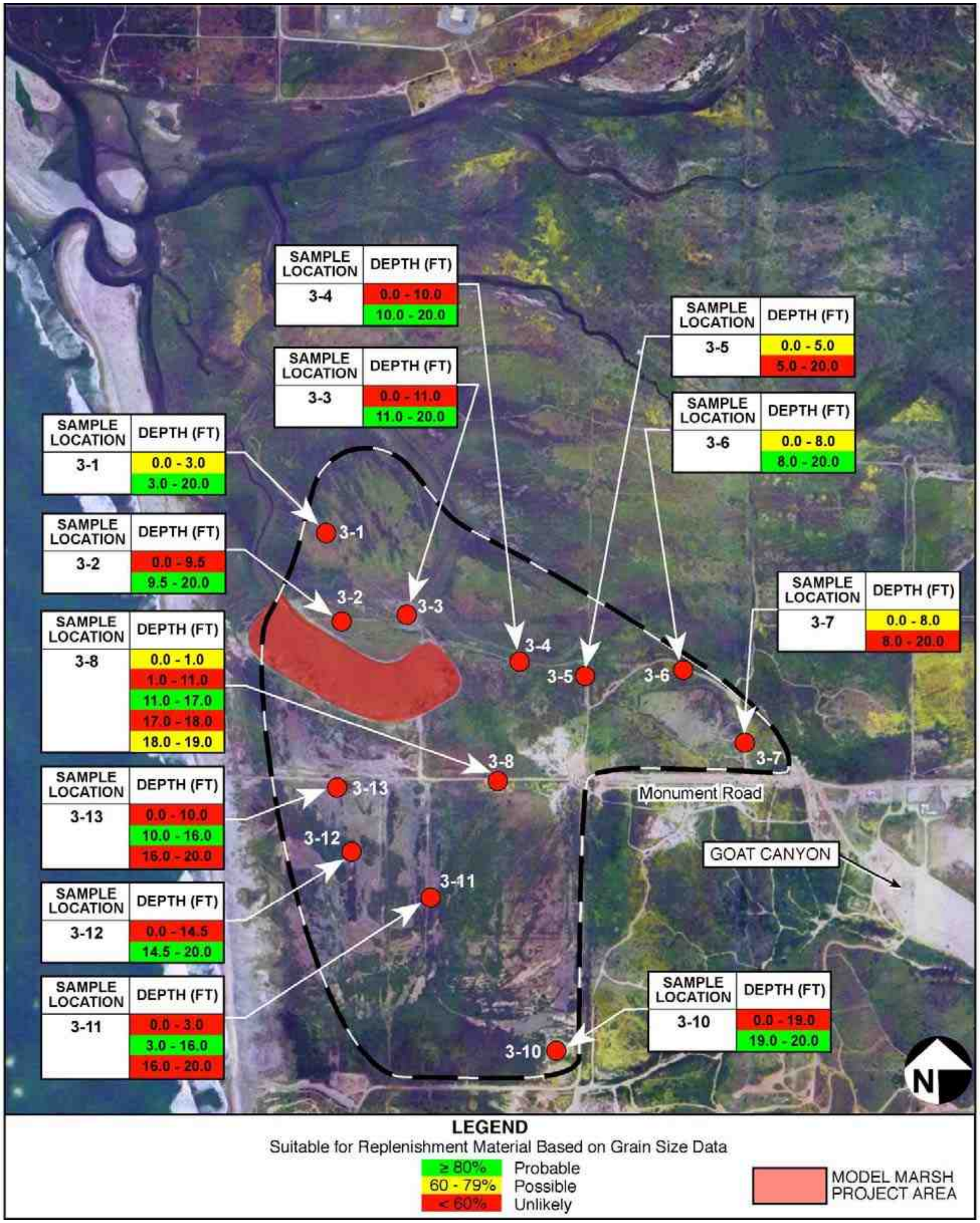


Figure 8-4. Grain Size Analysis Results for Site 3

suggest that areas north of the existing Model Marsh could be over excavated to find suitable sands for beach replenishment while most of the area south of the Model Marsh is too variable for such an operation (Figure 8-3).

Channel Samples. Sediment collected from estuarine channels located some distance away from the main channel (C-1, C-2 and C-3; Figure 8-1) were predominantly silt and clay (70% average) with some fine sand (30%). Station C-4, located near the terminus of the current channel of the Tijuana River, was predominantly sand 72%. The top 2 feet of sample C-5, located in the northern flow channel of the river, was 23% sand and 77% fines. From 2 feet bgs to 2.5 feet bgs, the material was 95% sand and 5% fines. Station C6, located near the tidal inlet, was 97% sand (96% of which was fine sand) with 3% fines.

Chemistry

For this report, the chlorinated pesticides DDT and its derivatives, DDE and dichlorodiphenyl-dichloroethane (DDD) are referred to as DDT.

Site 1. Chemical analyses were performed for the top strata from Stations 1-2 (0-5 feet bgs) and 1-7 (0-10 feet bgs). Analysis at Station 1-7 indicated that no significant metal or organic chemical contamination was present. The majority of the analyses results showed concentrations to be below detection limits. Phthalates were detected; however, they are common field and laboratory contaminants derived from the use of plastic materials. At Station 1-2, similar findings were observed with the exception of significant levels of DDT (48 micrograms per kilogram) exceeding the ER-M of 46.1 micrograms per kilogram, but not exceeding the EPA PRGs for residential soils (1,700 micrograms per kilogram).

Site 2. Chemical analyses were performed for the top strata from Stations 2-3 (0-4 feet bgs) and 2-4 (0-3 feet bgs). These analyses indicated elevated levels of DDT, with a concentration at Station 2-3 (48 micrograms per kilogram) and at Station 2-4 (210 micrograms per kilogram), both of which exceed the ER-M of 46.1 micrograms per kilogram. Metals and other organic contaminant were observed at low concentrations or at concentrations below detection limits.

Site 3. Chemical analyses were performed for the top strata from Stations 3-2, 3-3, 3-4and 3-10, 3-11, 3-13. Slightly elevated DDT levels were observed for the composite sample at Stations 3-2, 3-3, 3-4 with a concentration of 2.6 micrograms per kilogram, which exceeds the ER-L of 1.58 micrograms per kilogram.

The results of this preliminary analysis suggest that some strata are suitable for beach nourishment, but that those strata are not consistent across the project area. DDT and derivatives were detected in four of six composited surface samples, which would limit placement of these materials in the nearshore environment. It is not possible to delineate the extent or coverage of DDT and derivatives within the project area without additional chemical information from other sampling stations and strata. For those areas where total DDT concentrations exceed the ER-M (e.g., 1-2 and 2-4), it is unlikely that the material would be permitted for any in-water disposal scenario. Potential disposal options can include a variety of upland reuses, such as industrial fill or berm creation, as concentrations of other constituents were below criteria listed in the

RWQCB Basin Plan – Report of Waste Discharge (RWQCB 1994). Samples where total DDT concentrations are at or below the ER-L may be permitted for nearshore disposal, assuming that the material meets the grain size criteria.

Supplemental grain size analyses were conducted from samples collected from 48 trenches excavated for the purpose of examining the project site for buried cultural resources. The results depicted a generally heterogeneous distribution of sands and fines in the project area. No additional sediment chemistry was performed on these samples.

SECTION 9.0 CULTURAL RESOURCES

A total of 49 archeological investigations have been conducted within Tijuana Estuary. From these previous investigations, a literature review identified 7 previously recorded sites in the 570-acre expanded study area. These sites range from prehistoric to historic and include: temporary Native American food processing camps, tool making sites and Native American villages, as well as previous modern agricultural and military activities. A trenching study was conducted to examine the potential for buried cultural resources. A total of forty-eight trenches, each ten by one meter and three to four meters deep were excavated by backhoe. The locations of the trenches are presented in Figure 9-1.

The trenching study revealed two new sites: a Prehistoric shell midden, indicating a Native American food processing camp; and a collection of WWII-era hardware in oil drenched soil, providing evidence of military use of the area. No other sites, or significant cultural resources, were found in the project area. Therefore, no significant impacts are expected.

SECTION 10.0 RECREATION AND PUBLIC ACCESS

Tijuana Estuary has long attracted passive recreational users, such as birders and nature enthusiasts. The Tijuana Estuary Visitor Center, constructed in 1991, provides educational programs and displays that explain the ecology of the estuary. Numerous trails have been constructed around the visitor center and in other areas in the north arm of the estuary. These trails allow visitors to view selected portions of the estuary while restricting access to sensitive habitats and species.

California State Parks (CSP) and the U.S. Fish and Wildlife Service (USFWS), co-managers of the Tijuana River National Estuarine Research Reserve, developed a number of Reserve-wide policies regarding public access and public use. One such policy is to encourage wildlife-oriented recreation, including wildlife observation, photography, interpretation and education. Other forms of recreation, such as hiking, horseback riding and beach use are also encouraged wherever they are compatible.

FIGURE 9-1 **Location of Individual Trenches**

The Comprehensive Management Plan for the Tijuana River National Estuarine Research reserve and Tijuana Slough National Wildlife Refuge (Management Plan; CONCUR July 2000) identified a number of perceived needs for public access. Among them were:

- Improve Monument Road access through expanded entrance hours, enhanced roadway conditions, and additional roadside facilities, and

- Develop a large-scale effort to plan and improve accessibility to the southern end of the Reserve.

The Goat Canyon Enhancement Plan, completed in 2005, included improvements to Monument Road to provide better access to the Border Field State Park and the southern end of the estuary. Portions of the road were elevated, a multi-use trail was constructed along a portion of the road, and new entrance kiosk was constructed. However, a section of the road that was not elevated washed out during the heavy rainfall of 2005. This wash-out coupled with increased water flow and sediment deposition from Yogurt Canyon near Monument Mesa has continued to restrict entrance and use of Border Field State Park. The park is currently closed to the public.

The Management Plan also included perceived needs in public use. These included:

<u>Equestrian Trail Use Needs</u>.

- The operating agencies, landowning agencies, the Tijuana Equestrian Association and the Mounted Assistance Unit need to develop and implement a memorandum of understanding (MOU) relating to trail routing, maintenance and use.

- Wetland restoration projects in the southern end of the Reserve should integrate trail access needs and trails should be included in the engineering plans for marsh restoration projects.

- Proposals for any new recreation uses of the Reserve (e.g., mountain biking) must be carefully analyzed to ensure that they are compatible not only with resource protection, but also with existing authorized uses such as horseback riding.

Some of these perceived needs regarding public access and use have been addressed since the last revision of the Management Plan. For example, an MOU was developed between operating agencies and equestrians, and education efforts have been expanded. However, many of the perceived public use needs were associated with equestrian use of trails and the beach.

In order to accommodate equestrians and other trail users while complying with the identified need for integration of trail access needs in marsh restoration projects, alternate beach access routes have been devised. These are presented below.

Bridged Alternative. The most complex alternative would include an improved multi-use trail that would follow existing trails and the berm that currently protects the Model Marsh (Figure 10-3). This trail would be approximately 1.2 miles long and would feature a decomposed granite surface and include three prefabricated bridges. The trail would be 16 feet wide to accommodate multiple users, e.g., hikers and equestrians. This width would narrow to 12 feet at each bridge. The trail would be elevated to prevent damage from extreme tides expected once the tidal flushing in the southern arm is improved by the restoration plan. It is anticipated that the trail would be used by equestrians, hikers and bicyclists. Hikers and cyclists would be informed by signage to wait for any horses to cross the bridges should they arrive simultaneously.

The cost of the improved trail is illustrated in Table 10-1. Assuming that each prefabricated bridge will cost approximately $125,000, it is estimated that the 1.2-mile trail can be constructed for approximately $1,225,600.

Table 10-1. Multi-Use Trail - Estimate of Probable Construction Cost

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$10,000.00	$10,000.00
Clearing & Grubbing	1	LS	$10,000.00	$10,000.00
Grading/ Earthwork	10450	CY	$10.00	$104,500.00
Trail Surface	6110	LF	$20.00	$122,200.00
12' Wide Bridge (100' Span)	3	EA	$125,000.00	$375,000.00
Bridge Abutments (Pair) - Pilings	3	EA Pair	$80,000.00	$240,000.00
Slope Protection/ Landscape	5950	SY	$2.00	$11,900.00
			Subtotal:	**$873,600.00**
			5% Contingency:	$43,700.00
			25% Final Engineering/ landscape/ survey	$218,400.00
			10% (Bridge Cost) Structural Engineering	$37,500.00
			6% Soils Engineering	$52,400.00
			Environmental Services	*undetermined*
			Total:	***$1,225,600.00***

Construction of this trail would result in impacts to existing habitats (Table 10-2). Some of the impacts would be considered permanent, i.e., the existing habitats would be converted to trail. Temporary impacts associated with a 5-foot-wide construction buffer would be replanted with native species as mitigation. Permanent impacts total 3.46 acres and temporary impacts include 1.40 acres (Table 10-2).

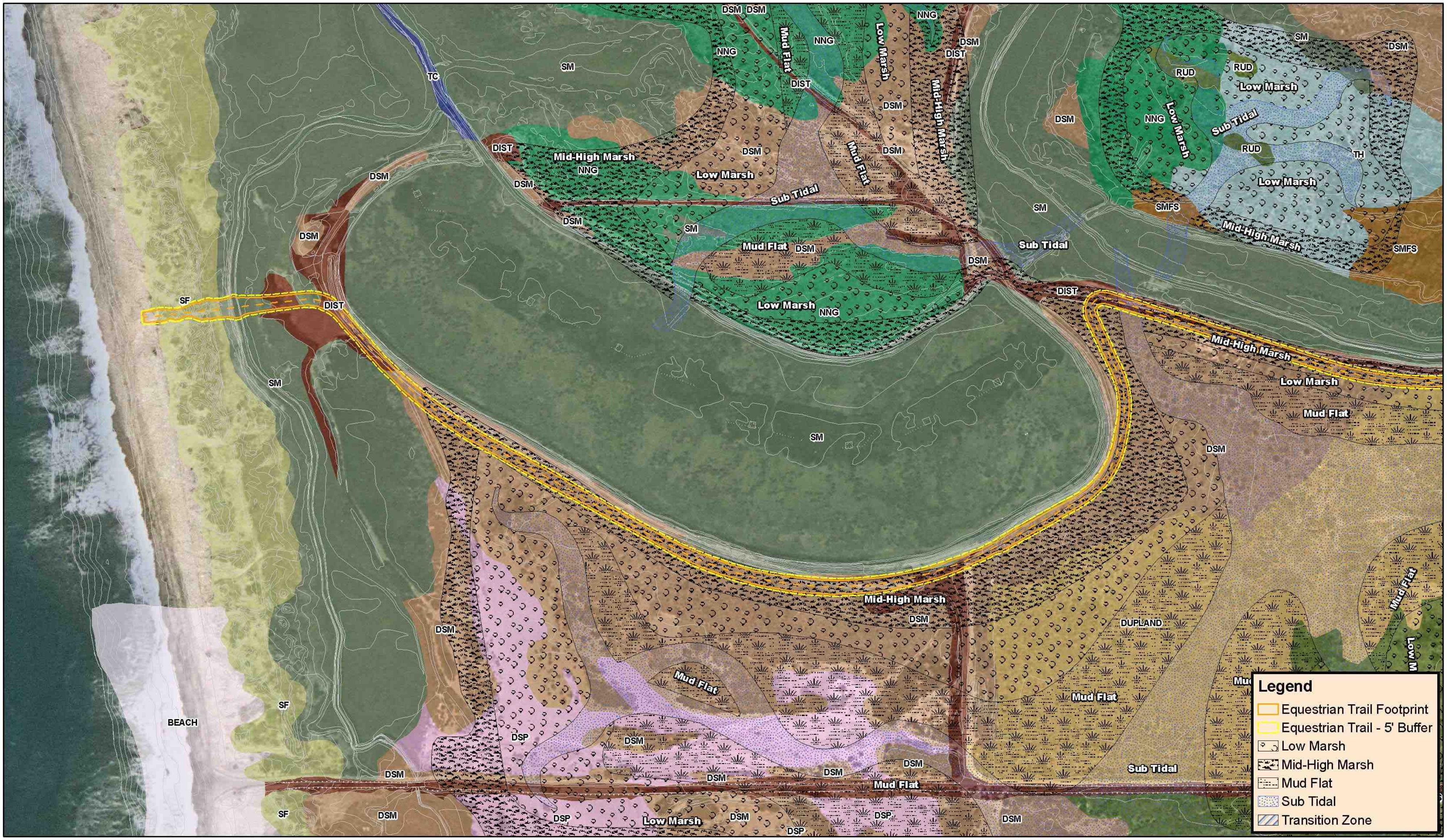


FIGURE 10-3.1
HABITAT IMPACTS - MULTI-USE TRAIL

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Exhibit Date: August 1, 2007
REC JN: 15431-A

0 100 200 400 Feet

Data Sources:
SanGIS Assessor Parcels: April 2006
SanGIS Roads - February 2006
Landiscor Aerial Photo: January 2006

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FIGURE 10-3.2

HABITAT IMPACTS - MULTI-USE TRAIL

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Exhibit Date: August 1, 2007

REC JN: 15431-A

0 100 200 400 Feet

Data Sources:
SanGIS Assessor Parcels: April 2006
SanGIS Roads - February 2006
Landiscor Aerial Photo: January 2006

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Table 10-2. Permanent and Temporary Impacts to Existing Habitats

Habitat_ID	Existing Habitat Description	Impacted Area - Multi-Use Trail (Acres) Permanent Impacts (Footprint)	Temporary Impacts (5' Buffer)	Total Impacts (FP + Buffer)
BM	Coastal Brackish Marsh	0.031	0.016	0.047
DIST	Disturbed	0.640	0.286	0.926
DMFS	Disturbed Mule-fat Scrub	0.000	0.0003	0.0003
DSM	Disturbed Southern Coastal Salt Marsh	1.550	0.592	2.142
DUPLAND	Disturbed Upland Habitat	0.616	0.241	0.857
MFS	Mule-fat Scrub	0.052	0.024	0.076
RUD	Ruderal	0.310	0.105	0.415
SF	Southern Foredunes	0.101	0.035	0.136
SM	Southern Coastal Salt Marsh	0.163	0.104	0.268
	Total (acres) =	**3.46**	**1.40**	**4.86**

Table 10-3. Restoration Area Habitat Impacts – Multi-Use Trail

Restoration Habitat Description	Impacted Area - Mulit-Use Trail (Acres) Permanent Impacts (Footprint)	Temporary Impacts (5' Buffer)	Total Impacts (FP + Buffer)
Low Marsh	0.077	0.068	0.145
Mid-High Marsh	2.620	0.977	3.597
Mud Flat	0.010	0.007	0.017
Sub Tidal	0.051	0.021	0.072
Total =	**2.76**	**1.07**	**3.83**

The construction of the proposed multi-use trail would result in a permanent reduction of approximately 2.76 acres of the proposed wetland habitat restoration associated with the Friendship Marsh Restoration Project Preferred Alternative (Table 10-3). The trail would also result in a temporary reduction of approximately 1.07 acres of the proposed wetland habitat restoration due to the construction footprint.

Other less costly alternatives were developed to accommodate trail users. These include the Spooner’s Mesa alternative and the Monument Road alternative, as described below.

Spooner's Mesa Alternative. The proposed Spooner's Mesa route would begin at Monument Road directly across from the newly constructed sediment retention basins at the mouth of Goat Canyon (Figure 10-4). From that point, trail users would travel across the sediment retention basins on a path leading south. This route would then take users up onto Spooner's Mesa using existing trails to a point near the international border. The trail would then turn west and descend from the mesa to reach Monument Road where users would follow the existing road and a short connecting trail to the beach. This alternate route avoids potential traffic on much of Monument Road and offers outstanding views from the mesa top.

The Spooner's Mesa alternative would require little in terms of trail construction. Unpaved roads exist along the route that would be utilized for hiking, cycling and horseback riding. Access would be limited during wet weather. In addition, much of this route is currently used by the Border Patrol and could pose problems with high volumes of users. Furthermore, the border fence project, an approved double fence project along the Mexico/U.S border, would prohibit construction of portions of this alternative.

Monument Road Alternative. A second alternate trail route would begin at the same juncture with Monument Road. However, this route would follow Monument Road first west, then south, and then west again toward the beach area. This route is only marginally longer (approximately 1,000 feet) than the route eliminated by the restoration. It also takes advantage of the existing wide road surface and avoids any strenuous grade changes between the origin trail and the beach (Figure 10-4). However, this route does place equestrians, as well as hikers and potentially bicyclists, near automobile traffic on Monument Road. If this alternative is selected, it is proposed that some type of visual barrier be erected on the final north-south and east-west segments to shield other users from vehicles.

Construction of the Monument Road alternative would impact areas previously impacted by sediment deposition and fresh water. These areas were formerly dominated by high salt marsh and salt panne, but have been degraded as described in Section 2.4.

SECTION 11.0 MATERIAL DISPOSAL OPTIONS

The disposal of materials excavated during this project is regulated by the U.S. Environmental Protection Agency, the U.S. Army Corps of Engineers, the California Regional Water Quality Control Board and other County and City permitting bodies as discussed in Section 8. Depending upon the characteristics of the excavated sediments, a number of disposal options were examined for this project. These are summarized below.

A) Beach, dune and nearshore replenishment at Tijuana Estuary. Under this disposal option, excavated sediments would be either pumped to the nearshore environment as a dredge-slurry or trucked to the beach and dunes for replenishment. Restoration of the barrier beaches and dunes would help to ensure that the estuary is protected from wave storms. This form of disposal also results in very low transportation costs. This option is limited by requirements regarding grain size and contaminant levels.

FIGURE 10-4 **Proposed Alternative Recreation Trail Alignments**

B) On-site disposal of excavated materials within a protective berm. One of the project goals is to protect the restored area from river borne sediments. Creation of a berm will protect the site and incur very low material transport costs. However, only a small volume of material is needed to construct the berm. Thus, this option does not provide for the disposal of significant amounts of excavated material.

C) Off-site disposal to various quarries and landfills. Six off-site quarries and one landfill were identified for potential disposal sites (Figure 11-2). Transporting material to a landfill is the least desirable alternative because of costs and disposal site availability. The cost for the landfill alternative varies according to the distance from the project and fees associated with disposal of material. In addition, the availability of space at existing landfills and mining sites will need to be reevaluated when project funding becomes available. The option of transporting materials to an existing quarry site has constraints similar to transporting to a landfill, e.g., distance from the project and availability of space as funding becomes available.

D) Open-water disposal at LA5. This high-capacity ocean disposal site could accept most of the materials excavated in this project. Limitations include the difficulty of pumping excavated materials to a barge and the high cost of disposal. In addition, chemically contaminated materials would not be accepted.

In summary, the least expensive disposal options are disposal to the beach or nearshore environment followed by disposal in a nearby quarry. Details on construction phasing and disposal are presented in Section 12.

SECTION 12.0 CONSTRUCTION ALTERNATIVES

The restoration project has been divided into five construction phases that allow costs to be estimated for each phase. For each of the five phases, five different material management alternatives (A through E) have been developed:

A Alternatives – A Alternatives entail excavating the required volumes of material and trucking this material off-site. The process is simple but results in high costs for material transport to distant disposal sites.

B Alternatives – B Alternatives use some of the excavated material for beneficial re-use on Tijuana Estuary beaches, dunes and nearshore areas. The remaining material will be trucked off-site. B Alternatives are usually less expensive than A Alternatives because less material must be trucked away (Table 12-1).

C Alternatives – C Alternatives maximize beneficial re-use by excavating below the finished grades of the restoration to reach additional sands suitable for re-use. The process of over-excavation is complex and requires material sorting and temporary storage. Material handling costs are higher, but overall costs may be less than A and B Alternatives because less material must be trucked away to distant disposal sites (Table 12-1).

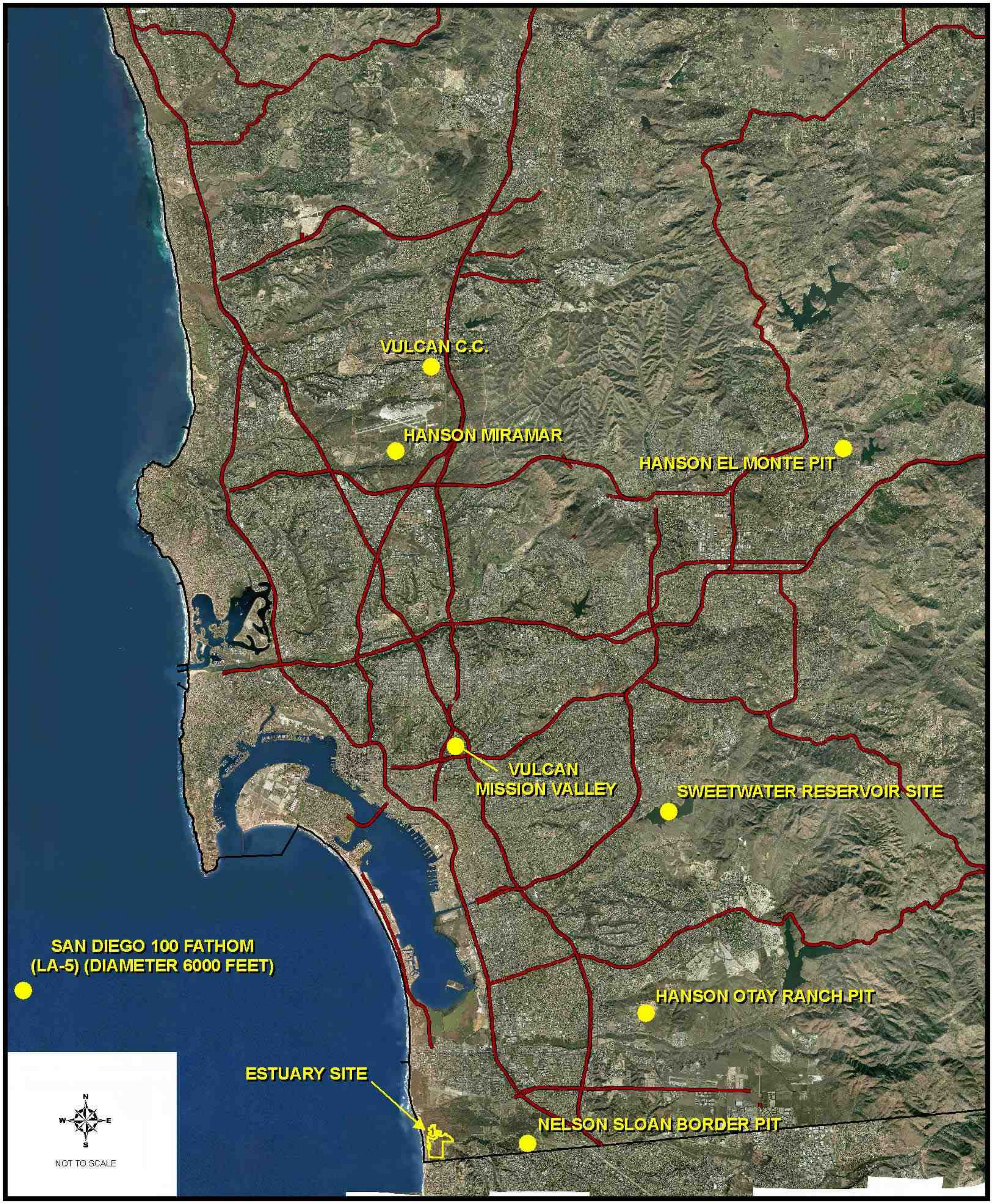

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FIGURE 11-2

Location of Potential Disposal Sites

Table 12-1. Disposal Options and Costs by Phase

Phase 1 - 39 acres	Cost	Berm ft³	Dune ft³	Beach ft³	Offsite ft³	Ocean ft³	TOTAL ft³	
Alternative A: No Beach + Far Offsite	$32,839,727	30,000			541,000		571,000	
Alternative B: Max Beach + Far Offsite	$29,821,713	30,000		74,000	467,000		571,000	
Alternative C: Over Ex Max Beach + Far Offsite	$24,601,953	30,000		287,000	254,000		571,000	
Alternative D: Max Beach + Ocean	$29,428,238	30,000		74,000		467,000	571,000	
Alternative E: Max Beach + Nearby Offsite	$13,559,785	30,000		74,000	467,000		571,000	
Phase 2 - 37 acres	**Cost**	**Berm ft³**	**Dune ft³**	**Beach ft³**	**Offsite ft³**	**Ocean ft³**	**TOTAL ft³**	
Alternative A: No Beach + Far Offsite	$18,778,855				319,000		319,000	
Alternative B: Max Beach + Far Offsite	$29,821,713		10,000		309,000		319,000	
Alternative C: Over Ex Max Beach + Far Offsite	$16,977,058		10,000	240,000	69,000		319,000	
Alternative D: Max Beach + Ocean	$17,071,243		10,000			309,000	319,000	
Alternative E: Max Beach + Nearby Offsite	$13,559,785		10,000		309,000		319,000	
Phase 3 – 75	**Cost**	**Berm ft³**	**Dune ft³**	**Beach ft³**	**Offsite ft³**	**Ocean ft³**	**TOTAL ft³**	
Alternative A: No Beach + Far Offsite	$49,233,610				901,000		901,000	Hanson El Monte (35 mi)
Alternative B: Max Beach + Far Offsite	$39,669,737			225,000	676,000		901,000	
Alternative C: Over Ex Max Beach + Far Offsite	$37,222,292			679,000	222,000		901,000	
Alternative D: Max Beach + Ocean	$37,379,267			225,000		676,000	901,000	
Alternative E: Max Beach + Nearby Offsite	$33,202,367			225,000	676,000		901,000	Hanson El Monte (29 mi)
Phase 4 - 32 acres	**Cost**	**Berm ft³**	**Dune ft³**	**Beach ft³**	**Offsite ft³**	**Ocean ft³**	**TOTAL ft³**	
Alternative A: No Beach + Far Offsite	$14,396,803				262,000		262,000	
Alternative B: Max Beach + Far Offsite	$13,194,238			34,000	228,000		262,000	Hanson El Monte (35 mi)
Alternative C: Over Ex Max Beach + Far Offsite	$15,118,888			262,000			262,000	
Alternative D: Max Beach + Ocean	$12,779,753			34,000		228,000	262,000	
Alternative E: Max Beach + Nearby Offsite	$10,987,003			34,000	228,000		262,000	Hanson El Monte (29 mi)
Phase 5 - 67 acres	**Cost**	**Berm ft³**	**Dune ft³**	**Beach ft³**	**Offsite ft³**	**Ocean ft³**	**TOTAL ft³**	
Alternative A: No Beach + Far Offsite	$37,932,679				592,000		592,000	Hanson El Monte (35 mi)
Alternative B: Max Beach + Far Offsite	$37,973,629				592,000		592,000	
Alternative C: Over Ex Max Beach + Far Offsite	$41,210,044			288,000	304,000		592,000	
Alternative D: Max Beach + Ocean	$31,075,465					592,000	592,000	
Alternative E: Max Beach + Nearby Offsite	$33,084,199				592,000		592,000	Vulcan CC (30 mi)

Cost Summary	Phase 1	Phase 2	Phase 3	Phase4	Phase 5	Total
Alternative A: No Beach + Far Offsite	$32,839,727	$18,778,855	$49,233,610	$14,396,803	$37,932,679	$153,181,674
Alternative B: Max Beach + Far Offsite	$29,821,713	$29,821,713	$39,669,737	$13,194,238	$37,973,629	$150,481,030
Alternative C: Over Ex Max Beach + Far Offsite	$24,601,953	$16,977,058	$37,222,292	$15,118,888	$41,210,044	$135,130,235
Alternative D: Max Beach + Ocean	$29,428,238	$17,071,243	$37,379,267	$12,779,753	$31,075,465	$127,733,966
Alternative E: Max Beach + Nearby Offsite	$13,559,785	$13,559,785	$33,202,367	$10,987,003	$33,084,199	$104,393,139

D Alternatives – D Alternatives employ beneficial reuse similar to B Alternatives, but the remaining material will be pumped to scow and then transported to the LA5 deep ocean disposal site. These disposal options are slightly less expensive than B Alternatives where materials are trucked to disposal sites. However, these options are generally more expensive than C Alternatives.

E Alternatives – E Alternatives employ beneficial re-use similar to B Alternatives, but emphasize the use of disposal sites close to the project area, i.e. at a nearby abandoned quarry. The goal is to minimize material transport costs, which are the major expense in all options.

A Alternatives are generally most expensive while E Alternatives are the least expensive. Neither A nor E alternatives accomplish the goal of replenishment and dune protection. The greatest cost for all options lies in the transport of material to disposal sites. The greatest savings are derived from beneficial reuse of the excavated material.

Environmental impacts will result from phased construction to restore former tidal elevations. However, at present, the vast majority of the project area is significantly disturbed by sedimentation, with only small fragments of undisturbed estuarine habitats remaining. Tidal flushing occurs only in the extreme northern portion of the project area. Most of the project area no longer functions as a tidal wetland and only remnant wetland vegetation remains. This habitat conversion due to sediment deposition is not reversible without excavating to restore intertidal elevations. Thus, some impact to areas that once were valuable habitat must occur. Overall, the creation of high functioning habitats, to replace severely degraded habitats, makes the project self-mitigating. Table 12-2 summarizes project impacts and the habitats to be created by phase. A detailed discussion of the concept of self-mitigation is presented in Section 12.

SECTION 13.0 RESTORATION PLANTING PLAN

The overall goal of the restoration project is to recreate both the functions and values of tidal wetlands. Thus, the restored marsh should be similar in all ways to undisturbed tidal wetlands. It should have a similar physical character, as well as distribution and proportion of habitats and plant and animal species.

Once the network of tidal basins and channels is complete, major plantings will occur from root divisions and propagules of plant species harvested on site. Other plantings will occur from container grown stock and seed. In addition, some salvage, storage and transplanting of existing salt marsh plants may occur. Initial plantings will occur in distributions and densities designed to produce 100% cover within 3 to 5 years. 80% survivorship of plantings is expected in year one. Any failing plantings will be replaced to ensure 100% survivorship after the first year.

The successful establishment of plantings in the now complete Model Marsh will also be used as a guide to habitat planting; specifically, to guide initial planting techniques and densities. Some aggressive plant species are expected to re-invade the site naturally. Appropriate irrigation and maintenance (especially weeding) will occur where necessary to ensure plant survivorship.

The planting plan is presented in Figure 13-1.

Table 12-2. Project Impacts by Proposed Phase

	Phase 1 – 39 acres			Phase 2 - 37.3 acres			Phase 3 – 74.9 acres			Phase 4 – 31.7 acres			Phase 5 – 67.3 acres		
	Impact			Impact			Impact			Impact			Impact		
	Pristine	Disturbed	Creation	Pristine	Disturbed	Creation	Pristine	Disturbed	Creation	Pristine	Disturbed	Creation	Pristine	Disturbed	Creation
Tidal Open Water			22.9	0.02		7.7			13			5.5			12
Channel															
Mudflat			6.1			6.1			18.3			11.5			18.5
Low Salt			4.1			10.8			23.7			5.5			15.9
Mid-High Salt			3.1			12.7			19.9			9.2			16.3
High Salt															
Salt Marsh Subtotal	***0.06***	***4.93***	***7.2***	***1.34***	***12.46***	***23.5***	***0.56***	***16.79***	***43.6***		***17.14***	***14.7***		***7.53***	***32.2***
Brackish Marsh							0.01							45.33	
Salt Marsh Fleabane Scrub				0.49			0.07								
Salt Panne		0.36						4.47			13.08			2.48	
Mule-fat Scrub		22.73					1.84	13.97			0.22			8.06	
Southern Willow Scrub								0.89							
Saltbush Scrub								2.72							
Tamarisk Scrub								0.45							
Ruderal		7.67			0.32			8.46						3.66	
Transition			2.5	4.14											4.6
Non-native Grassland				17.49											
Upland		1.99						20.23			0.14				
Developed														0.06	
Disturbed		1.02			1.55			4.55			1.19				
Total	**0.06**	**38.7**	**38.7**	**23.03**	**14.33**	**37.3**	**2.48**	**72.53**	**74.9**		**31.77**	**31.7**		**67.12**	**67.3**
Total Impact	**38.76**			**37.36**			**75.01**			**31.77**			**67.12**		

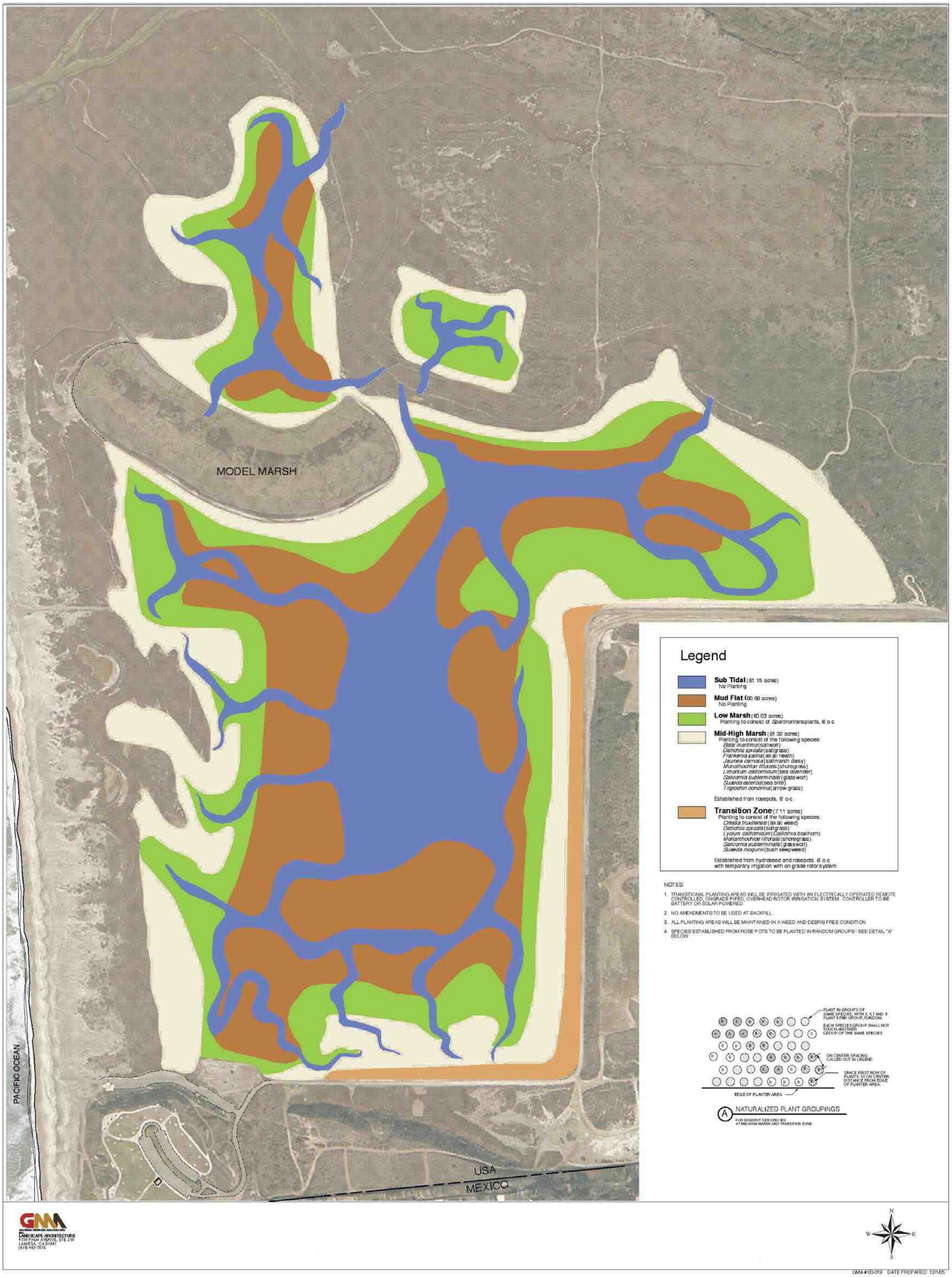


FIGURE 13-1 **Preliminary Habitat Planting Plan**

SECTION 14.0 PROJECT EVALUATION METHODS AND SUCCESS CRITERIA

As mentioned in Section 3.0, success criteria were established a priori for each project component and goal.

Goal 1.	Increase tidal prism through habitat creation.
Goal 2.	Restore areas of former salt marsh, tidal channel, and mudflat affected by sedimentation to the maximum extent possible (to 1850's status).
Goal 3.	Restore barrier beach and dunes.
Goal 4.	Increase habitat for endangered species.
Goal 5.	Increase area of undisturbed transition zone.
Goal 6.	Build in topographic relief (a protective berm) to prevent loss of restored habitat due to flood events.
Goal 7.	Incorporate research and adaptive management.

Evaluation of project success will involve the collection of both quantitative and qualitative data. These data include both physical (hydrology, topography, soils) and biological forms (vegetation, aquatic biota, birds).

Long-range evaluation will be completed through iterative monitoring which allows for adaptive management. As results are compiled, data collection techniques and management processes can be improved or altered. The overall goal is to refine monitoring methods to increase restoration success.

Monitoring will be conducted after each phase is completed, after completion of the entire project, and annually thereafter for a number of years (as yet to be determined).

SECTION 15. ADDITIONAL ANALYSES AND NEXT STEPS

This section addresses issues that, though recognized as important, were not addressed in this feasibility study due to time and funding constraints. These issues include global climate change, a study of the fate and transport of sediment disposed of in the nearshore environment, and additional engineering and environmental tasks including, but not limited to, refinement of engineering plans, sediment testing, analysis of recreational trails, habitat mapping, environmental documentation and acquisition of discretionary permits. It is anticipated that any necessary analyses will be conducted in the near future, prior to or concurrent with final engineering and environmental document preparation.

Global Climate Change

Due to predictions of climate change and associated sea level rise, the Southern California Coastal Water Research Project (SCCWRP) proposed, in 2007, a study plan that would address the impacts of global warming on coastal wetlands using idealized, model systems. Although the study plan was not compatible with this feasibility and design study, the planned TRNERR represents an excellent opportunity to translate model outcomes into decision-making and project implementation. It is anticipated that the following tasks outlined in the SCCWRP proposal could be applied to the TRNERR to gather information useful in modeling the effects of global climate change on coastal wetland restoration:

1. Summarize Existing Information. Review and summarize recent studies of climate change for coastal southern California and conduct interviews with experts working in this field. Emphasis should be given to existing models of changes in temperature, sea level, rainfall and runoff.

2. Estimate Effects of Terrestrial Forcing Functions. Using a synthetic watershed approach, two primary terrestrial forcing functions – run off and sedimentation – should be investigated. These synthetic watersheds would represent a range of physical conditions, including soil type, evapotranspiration, slope, and depth to ground water, that exist in southern California.

3. Estimate Effects of Oceanic Forcing Functions. A series of synthetic oceanic models should be constructed to assess changes in key oceanic physical factors such as coastal geomorphology, sea level rise and shoreline accretion and erosion.

4. Characterize Expected Change in Wetland Extent and Distribution, including biological responses to climate change. The focus of this step should be to predict changes in wetland extent and distribution including changes in inundation, scour and sedimentation. This should be accomplished through the use of historical mapping, data, and interviews with regional experts.

Adaptive management would be employed in order to account for the effects of both the immediate, short-term challenge of sediment deposition and the long-term challenge of anticipated sea level rise at Tijuana Estuary. The multi-phase approach to restoration would facilitate the use of adaptive management as the initial stages of the project would focus on sediment accretion; subsequent stages of the project would incorporate data collected on sea level rise.

Additional Engineering and Environmental Tasks

The preferred restoration alternative presented in this feasibility and design document is conceptual. Prior to project construction, engineering plans must be refined to provide a level of detail needed to acquire a grading permit and other discretionary permits from regulatory agencies. This will likely involve the modification of proposed grading contours to create restoration areas that more closely resemble natural areas. Refinement of engineering plans may also require minor design changes as a result of subsurface investigations and recreational trail alignment. The existing habitat map also must be refined. The most recent map of habitat in the Tijuana Estuary was compiled in 1986. It is anticipated that a detailed mapping effort will be undertaken to allow comparisons with the 1986 map and to accurately document changes due to sediment deposition and restoration projects.

Additional anticipated environmental tasks include quantification of soil excavation, preparation of a sediment disposal plan, and preparation of final bid documents and the engineers' cost estimate. The completion of these tasks is contingent upon final soil testing that will delineate portions of the project area that demonstrate the presence of DDT derivatives.

An Environmental Impact Report (EIR) pursuant to the California Environmental Quality Act (CEQA) will be required prior to the construction of the phased project. An EIR requires analysis of project alternatives and provides a process for public comment. It is anticipated that the California State Parks (CSP) will act as the lead agency and that the U. S. Fish and Wildlife Service, the California Coastal Commission, and the cities of Imperial Beach and San Diego and perhaps other agencies will participate as cooperating agencies.

Results from the Fate and Transport study, currently in the planning stages, also will influence the sediment disposal plan and, thus, will likely affect the final estimate of cost for restoration at the TRNERR. The Fate and Transport study was developed in coordination with the U. S. Geological Survey (USGS) to study the fate of fine-grained sediment once it enters the nearshore environment. The study proposes to assess the extent and duration of turbidity and burial of species/habitat when material with greater than 20% fine sediment (the standard limit for fine sediment disposed in the ocean) is used for beach nourishment. Material comprised of between 27% and 46% fine sediment will be transported from debris basins at Goat Canyon to the nearshore marine zone at Tijuana Estuary. Through physical and biological monitoring, this study seeks to 1) determine the transport pathways and impact of fine-grained sediment introduced at the shoreline; and to 2) assess how environmental and project variables influence rates and modes of sediment transport, and the eventual fate of sediment.

TIJUANA ESTUARY – FRIENDSHIP MARSH RESTORATION FEASIBILITY AND DESIGN STUDY

1.0 INTRODUCTION

The Tijuana Estuary – Friendship Marsh Restoration Feasibility and Design Study is a proposed multi-phase restoration of approximately 250 acres of degraded habitat located in the southern portion of Tijuana Estuary, San Diego County, California. The project has been designed to restore salt marsh, mudflat, tidal channel and subtidal habitats that have been filled over the past several decades, and to increase the tidal prism of the estuary.

The south arm of Tijuana Estuary has been subjected to degradation by human activities and from natural events. Zedler and Nordby (1986) documented historical land uses in the southern end of the estuary, including farming and military activities, that resulted in direct filling and loss of wetland habitats. The Tijuana River National Estuarine Sanctuary Management Plan (Management Plan; James Dobbin Associates 1986) concluded that the estuary had experienced a broad range of disturbances both directly on-site and indirectly through modifications of its watershed. Specifically, untreated sewage discharges from Mexico, hypersalinity associated with closure of the tidal inlet in winter of 1983-1984, unseasonal discharges from Rodriquez Reservoir in Mexico, inland migration of the barrier beach that separates the estuary from the ocean, and deposition of sediment borne by flows of trans-border canyons have contributed to the degradation of the estuary.

By the late 1980s, erosion and sedimentation associated with trans-border canyons were recognized as critical physical factors contributing to the loss of habitat in southern Tijuana Estuary (CONCUR 2000). Goat Canyon, with 90% of it’s watershed in Mexico, was identified as a source of sediment that had filled tidal channels and converted salt marsh to upland habitats dominated by non-native plant species. The development of plans to manage sediment on a local and watershed basis were categorized as high priority management objectives.

In 1988, the California Coastal Conservancy (Conservancy) funded the Tijuana Estuary Tidal Restoration Program (TETRP) in response to the 1986 Management Plan and subsequent analyses that documented the decline in resource values and the need for restoration in the estuary. An Environmental Impact Report/Environmental Impact Statement (EIR/EIS) was produced in 1991 (ENTRIX et al. 1991) following a series of biological and hydrological studies of the estuary. Those studies concluded that a rapid and perhaps catastrophic loss of sensitive biological resources could occur unless action was taken to reverse the trends of habitat loss and deterioration. The key findings and recommendations of the 1991 TETRP EIR/EIS were:

- Wetland habitats at Tijuana Estuary have been reduced in area by approximately 60% while the tidal prism of the estuary, based on analysis of an 1852 map of the estuary, has been reduced by about 80% (from 1550 acre-feet in 1852 to 290 acre-feet in 1991).
- The reduction in tidal prism has significantly reduced the tidal scouring of the tidal inlet, causing it to become unstable and susceptible to closure.

- The reduction in tidal prism has been caused by the following:
    1. Sedimentation during episodic flooding of the Tijuana River;
    2. Sedimentation in intertidal mudflats and conversion to intertidal marsh plain;
    3. Sedimentation from tributaries to the Tijuana River due to watershed instability;
    4. Inland migration of the barrier beach due to the effects of sea level rise, destabilization of barrier dunes due to vegetation removal, and dune overwash during periods of severe wave action;
    5. Filling and road construction.

The EIR/EIS concluded that "if no action is taken, it is possible that within two decades substantial additional tidal prism will be lost resulting in the nearly permanent closure of the tidal inlet and the conversion of the remainder of the wetland to salt flats or stagnant brackish and freshwater marsh."

The following actions were recommended in the 1991 EIR/EIS.

1. Excavate approximately 5,000,000 cubic yards of sediment in the southern arm of the estuary to recreate approximately 495 acres of tidal channels, mudflats and marsh plain and restore the tidal prism to its 1852 volume.
2. Construct the project in phases with Phase 1 including a 2.5-acre pilot project in the extreme northern end of the estuary, the widening of the main channel leading to the northern arm of the estuary, and construction of a 20-acre Model Marsh in the southern arm.
3. Construct "training levees" from excavated sediments to minimize river-borne sediment deposition in the newly created habitats.
4. Deepen and widen the main channel leading to the northern arm of the estuary.
5. Excavate upland and filled areas in the northern arm to create additional wetland area.
6. Reestablish dune vegetation on the barrier beach.

Of the major recommendations included in the EIR/EIS, only the first phase projects were implemented, including construction of the Oneonta Slough Tidal Connection (1997) in the estuary's north arm and the 20-acre Model Marsh (2000), in the southern arm. Widening of the main channel and excavating upland areas in the northern arm were omitted due to environmental constraints. Future potential phases were deferred when construction of river "training levees" was not approved by regulatory agencies. The concept of using excavated sediments for nourishment of the depleted dunes and beach was deferred to later studies.

In 2003, the consultant team was selected by a committee comprised of the Conservancy, Southwest Wetlands Interpretive Association (SWIA) and California State Parks to conduct a feasibility and design study for restoration of the southern arm of the estuary. The consultant team reviewed the documents generated for the 1991 EIR/EIS; assessed their validity under current physical and biological conditions; conducted additional studies of river hydrology and hydraulics, coastal processes, biology, cultural resources, and sediment characteristics; and developed new alternatives for restoration. This document presents the results of the feasibility and design study.

1.1 Current Study

This feasibility and design study reexamines the potential for restoration of the southern arm of Tijuana Estuary. One of the primary objectives of the project was to reevaluate the Tijuana Estuary Tidal Restoration Project (TETRP) as it was designed in the early 1990s, and refine and update that plan so that a programmatic-level feasibility analysis and engineering plan could be produced. This programmatic-level document will identify phases or modules that can be constructed as funding becomes available. Prior to construction of each phase or module, it is anticipated that more detailed analyses will be required and that the final design may be different from this conceptual design. The first step in this current study was to review the TETRP documents and all other available data so that data gaps could be identified. The next step was to design and implement a program to address data gaps. Once these steps were accomplished, other tasks, such as preparing the GIS database, and developing and analyzing project alternatives, could be undertaken.

The programmatic-level feasibility analyses focus on physical and biological constraints of the restoration. Ultimately, the objective of these analyses is to identify a Preferred Restoration Alternative. The major tasks undertaken in this analysis included:

1. Collect and Assemble Existing Data on the Following Subjects:
    - Geomorphic setting
    - Climate
    - Estuarine bathymetry, hydrology and hydraulics
    - Sediment characteristics
    - Coastal processes
    - Hydrology of the Tijuana River and its tributaries
    - Erosion and sedimentation characteristics of the Tijuana River and its tributaries
    - Vegetation
    - Wildlife
    - Special status species/sensitive habitats
    - Cultural resources
2. Identify Data Gaps
3. Prepare Plans to Address Data Gaps
4. Implement Plans to Address Data Gaps
5. Assess Regional Habitat Goals/Review TETRP Goals
6. Perform Technical Assessment of the No Action Alternative
7. Establish Project Goals and Objectives

8. Assess Disposal Alternatives
9. Develop Restoration Alternatives
10. Develop Detailed Plans for the Preferred Alternative
11. Develop Monitoring Protocols

A number of interim documents were produced in response to the tasks outline above. These have been summarized in this report.

Based on the results of the data review and constraints analyses presented above, the restoration design was developed. Within the context of project constraints, the project was designed to maximize habitat restoration and tidal prism, as well as habitat for sensitive species. In particular, project design incorporates the physical constraints posed by the Tijuana River and its tributaries and the goals and objectives of the restoration as determined by the project Technical Advisory Committee and the Tijuana River Estuary Research Reserve Research and Restoration Committee. Consequently, the Preferred Alternative identifies the restoration of approximately 250 acres of intertidal and subtidal channel, intertidal mudflat, intertidal low salt marsh and intertidal mid/high salt marsh.

2.0 EXISTING CONDITIONS - OVERVIEW

Tijuana Estuary is a dynamic system subject to natural fluctuations in rainfall, river hydrology, erosion, sedimentation, sea level rise, and wave action, as well as man-made changes brought about by diking and filling, dams and uncontrolled land use practices in Mexico. The system has changed much over the past century and, in some cases, has changed dramatically in the past two decades since the estuary was first studied for large-scale restoration. During that time, sedimentation from Goat Canyon (a north/south trending canyon with approximately 90% of its watershed in Mexico) has resulted in a measurable loss of tidal prism in the southern arm of the estuary. Tidal channels have been filled with sediment and become colonized by mid/high salt marsh vascular plant species, particularly pickleweed (*Salicornia virginica*). This colonization has resulted in further accretion of sediments and additional loss of tidal prism. In some areas, sedimentation has smothered coastal salt marsh, converting this valuable and rare habitat to weed-dominated ruderal habitats. The continuing degradation and loss of habitat within the southern arm of Tijuana Estuary underlies the urgency of designing and implementing a comprehensive restoration program.

2.1 Project Setting

Tijuana Estuary is located in the southwestern corner of the United States, immediately north of the U.S./Mexico border (Figure 2-1). The estuary consists of a northern arm, known as Oneonta Slough, a central estuary dominated by the Tijuana River, and a southern arm that follows one historic path of the Tijuana River (Figure 2-2). The Tijuana River has changed course several times in recent history. The tidal inlet is located roughly in the central estuary and is primarily influenced by tidal action during dry periods and by riverine processes, e.g., scour and sedimentation, during and immediately after flood events.

The estuary is continuously undergoing geomorphic evolution and is affected by both coastal and fluvial processes, including nearshore coastal changes, longshore and cross-shore sediment transport processes, tidal flows, episodic river flows and wave storms. The location and configuration of the tidal inlet changes in response to both tidal flows that scour the inlet and to wave-driven longshore and cross-shore transport that move sand into the inlet.

A barrier beach defines the western boundary of the estuary, both north and south of the tidal inlet. This beach is approximately three miles long and varies from about 100 to 500 feet in width. The barrier beach historically protected the tidal channels of the estuary from beach sand movement. However, with construction of condominiums on the beach and destruction of natural vegetation by recreational users, the destabilized beach and dune sands have been pushed into the estuarine channels during periods of high tide coupled with storm surge. This deposition has contributed to loss of tidal prism at Tijuana Estuary (Zedler and Nordby 1986; Zedler et al. 1992). In addition, construction of dams on the Tijuana River and its tributaries has blocked the delivery of sand to the Silver Strand littoral cell resulting in continual erosion of the barrier beach.

FIGURE 2-1 **Regional Location Map**

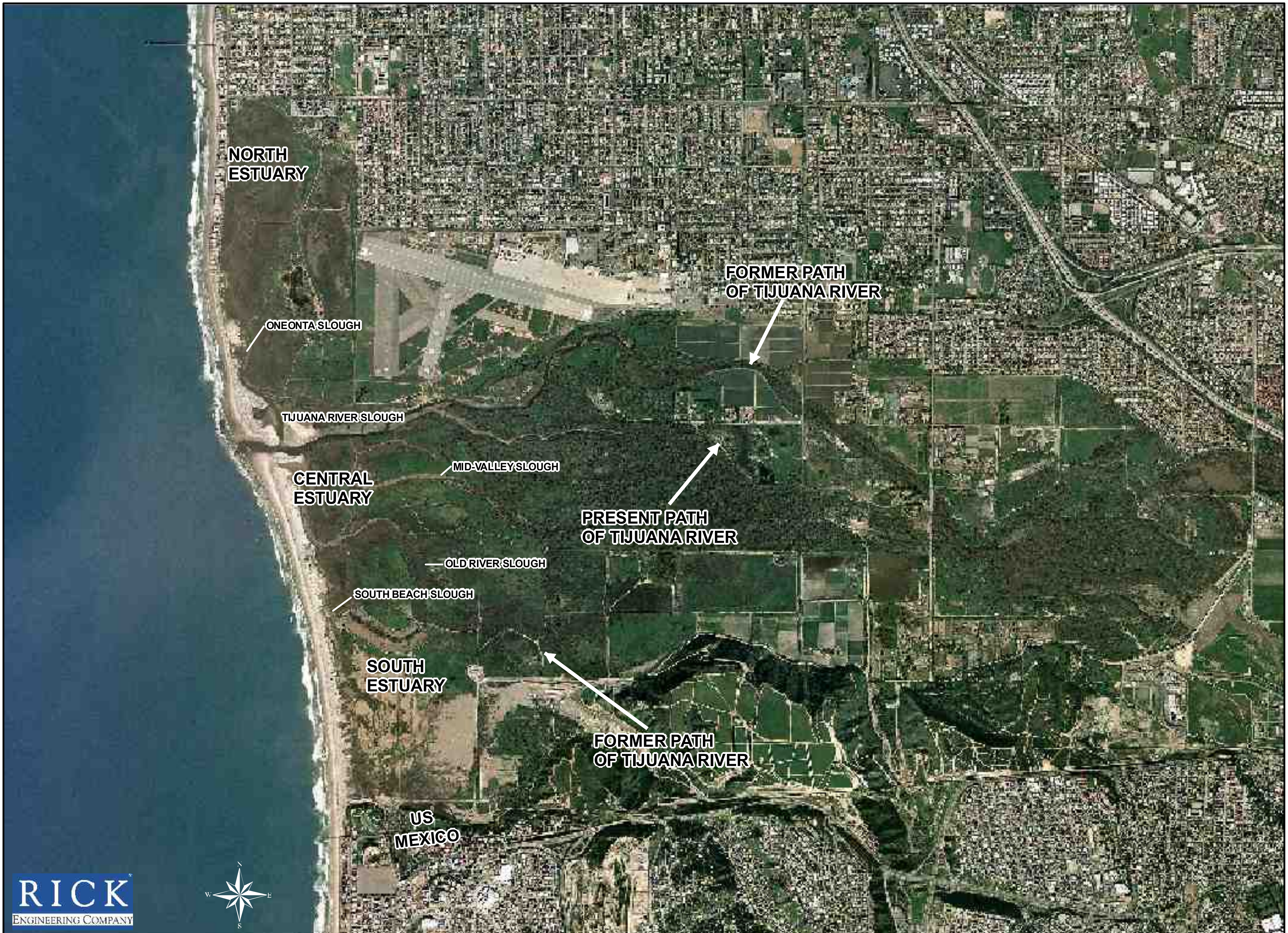


FIGURE 2-2 Aerial Overview of Tijuana Estuary

The northern arm of the estuary remains relatively pristine because it has largely escaped the wetland filling activities associated with agriculture and military uses more common in the southern arm of the estuary (Zedler and Nordby 1986; Zedler et al. 1992). The northern arm of the estuary and portions of the central estuary have been designated as the Tijuana Slough National Wildlife Refuge by the U.S. Fish and Wildlife Service.

The Tijuana River has followed a meandering path across its floodplain with former flows evident to the south and north of its current position (Figure 2-2). Old river channels now serve as estuarine tidal channels in the central portion of the estuary, although these too have been affected by sedimentation.

The southern arm has been heavily impacted by filling and diking for agriculture and military use, and more recently, by sedimentation borne across the border from Mexico. Much of the south arm was used as a training field by the U.S. Navy during World War II and is currently designated as Border Field State Park (Figure 2-3), a feature of the California State Parks system. Loss of tidal prism and coastal salt marsh has been documented in this portion of the estuary and is presented in detail in this report.

Tijuana Estuary was designated a National Estuarine Sanctuary in 1982 by the National Oceanic and Atmospheric Administration (NOAA) and later renamed the Tijuana River National Estuarine Research Reserve (Research Reserve). The Research Reserve encompasses approximately 2,531 acres of tidal and non-tidal land extending north from the U.S./Mexico border (Figure 2-3). The Research Reserve includes both the Tijuana Slough National Wildlife Refuge and Border Field State Park.

The health of an estuary is a function of its watershed and no estuary demonstrates that relationship more clearly than Tijuana Estuary. The estuary's watershed encompasses approximately 1,700 square miles with roughly 73% (1,245 square miles) located in Mexico and 27% (455 square miles) located in the U.S (Figure 2-4). The Tijuana River is formed by the confluence of the Rio de las Palmas and the Rio Alamar in Mexico, and then flows for approximately 17 miles to the Pacific Ocean. The Tijuana River crosses the international border just north of the City of Tijuana, Baja California, Mexico, approximately 5 miles east of the ocean. The present study area occurs within this last five miles of the watershed.

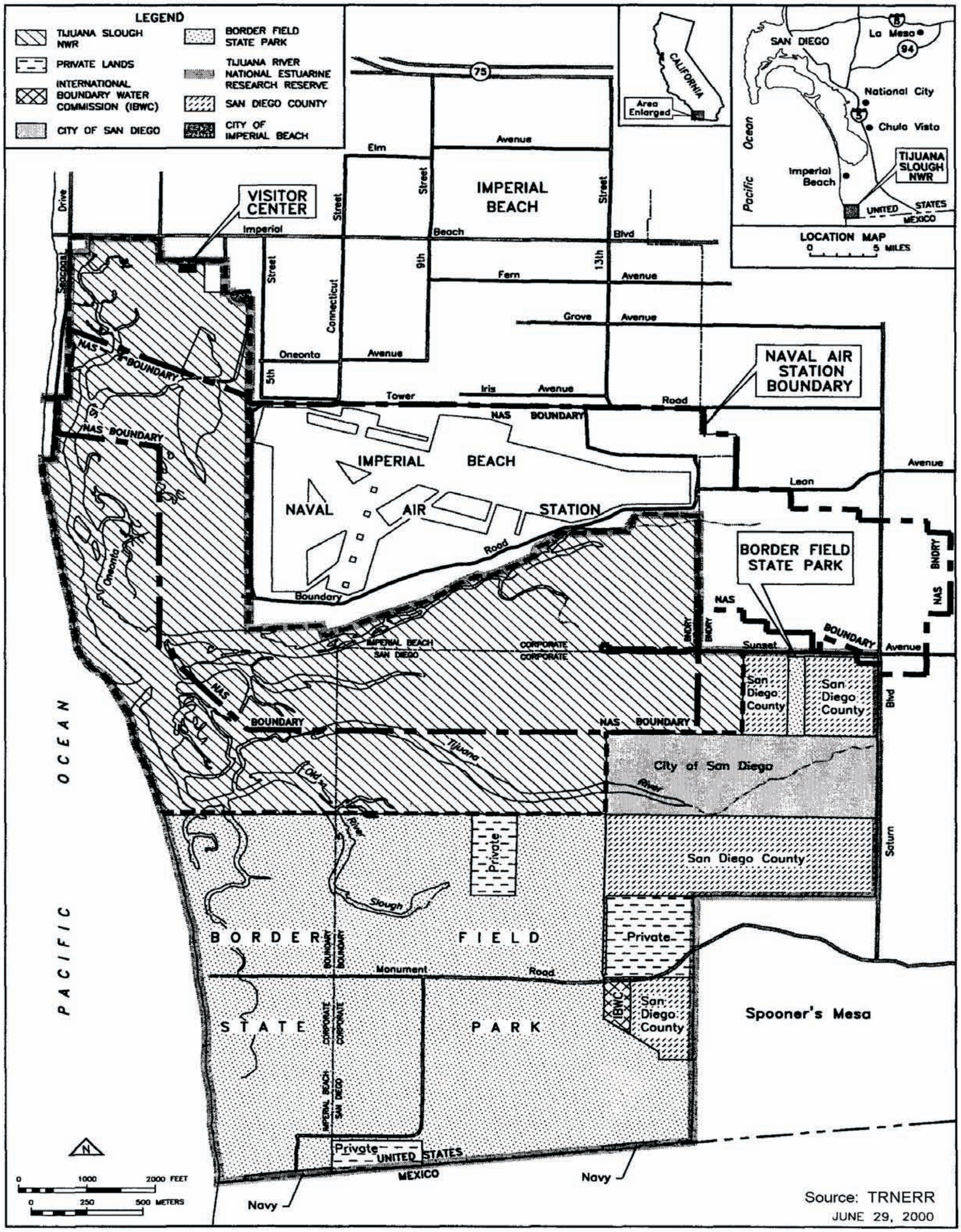


FIGURE 2-3 Current Land Ownership at Tijuana River National Estuarine Research Reserve

FIGURE 2-4 **Tijuana River Watershed**

Source: CESAR, San Diego State University

2.2 Historical Ecology

In the mid1850s, the U. S. Coast Survey began a mapping program of the California coastline. The maps ("T-sheets") created in this effort were focused on coastal navigation. One of the earliest maps, completed in 1852, included south San Diego Bay and Tijuana Estuary (Figure 2-5). Draft digital data and habitat interpretation of Tijuana Estuary in 1852 were acquired from the South Coast Historical T-sheets Project of SFEI, CSUN, SCCWRP, and the State Coastal Conservancy. Habitat interpretation was determined through extensive examination of the original map and related references conducted by Robin Grossinger, Scientist and Director, Historical Ecology Program, San Francisco Estuary Institute. Based on this analysis, it is estimated that approximately 400 hectares (988 acres) of estuarine habitat in 1852, as indicated in Figure 2-6 and summarized in Table 2-1.

TABLE 2-1. TIJUANA ESTUARY 1852 HABITAT SUMMARY

HABITAT	Area (ha/acres)	% Total
Beach	24.32/60.09	6.08%
Subtidal	9.14/22.58	2.28%
Dune	21.68/53.57	5.42%
Open water (intertidal)	7.83/19.34	1.96%
Open water (non-tidal)	9.07/22.41	2.27%
Mudflat (intertidal)	73.19/180.85	18.29%
Salt marsh (intertidal)	236.35/584.02	59.07%
Salt marsh (non-tidal)	11.50/28.42	2.87%
Upland	7.04/17.40	1.76%
Total	400.12/988.68	100.00%

For comparison with today's conditions, the 1852 map was overlain on an aerial photograph of the south San Diego Bay and Tijuana Estuary (Figure 2-7). A close-up of a similar overlay of the project area is presented in Figure 2-8.

In 1852, extensive areas of intertidal mudflat existed in the north, central and south arms of the estuary. The tidal salt marsh habitat in the northern arm appeared to be very similar to that of the estuary today. However, an extensive tidal marsh that existed in the south arm of the estuary in 1852 has since been lost. The shoreline profile appears to have changed little since 1852, with limited migration eastward. Tidal channels extended well east, off the mapped area. The large areas of intertidal channel, mudflat and tidal marsh indicated a greater tidal prism than exists today. The 1852 tidal prism has been calculated to be 1,550 acre-feet (ENTRIX et al.1991).

The 1852 map also shows prominent upland features extending into the tidal marshland (Figures 2-5 and 2-6). Upland extensions near the mouth may have functioned as river training berms, directing flows to the central portion of the estuary, thereby reducing flows and sedimentation to the south arm.

To illustrate the differences between the habitats inferred from the 1852 map and the modern day estuary, the 1852 map was overlain on a 1986 habitat map of the estuary. (Figure 2-9) The most notable changes include the change in the configuration of the tidal channels, the extensive loss

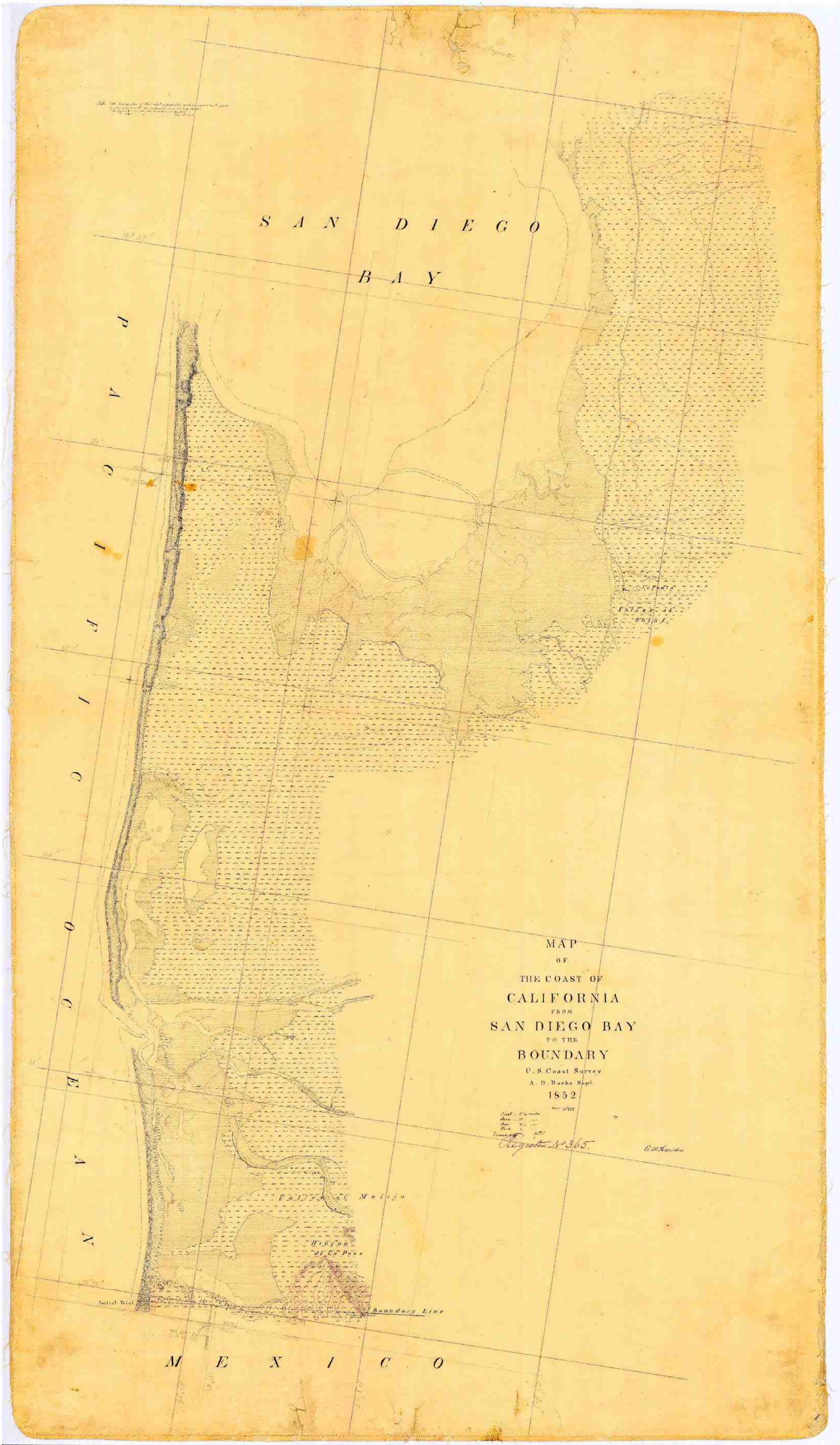


FIGURE 2-5 **1852 US Coast Survey Map of Tijuana Estuary**

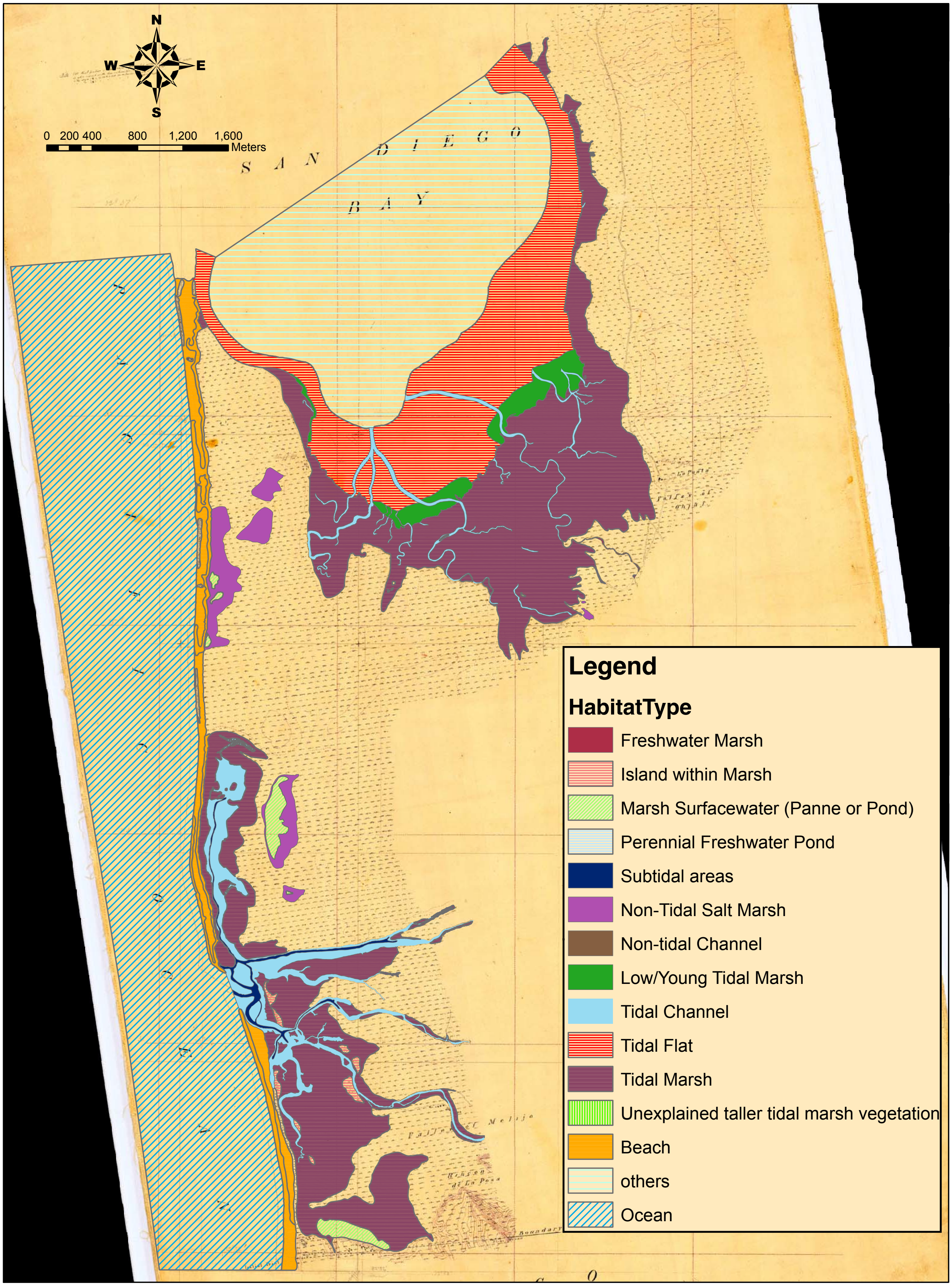


FIGURE 2-6 Habitats Inferred from 1852 Map of Tijuana Estuary

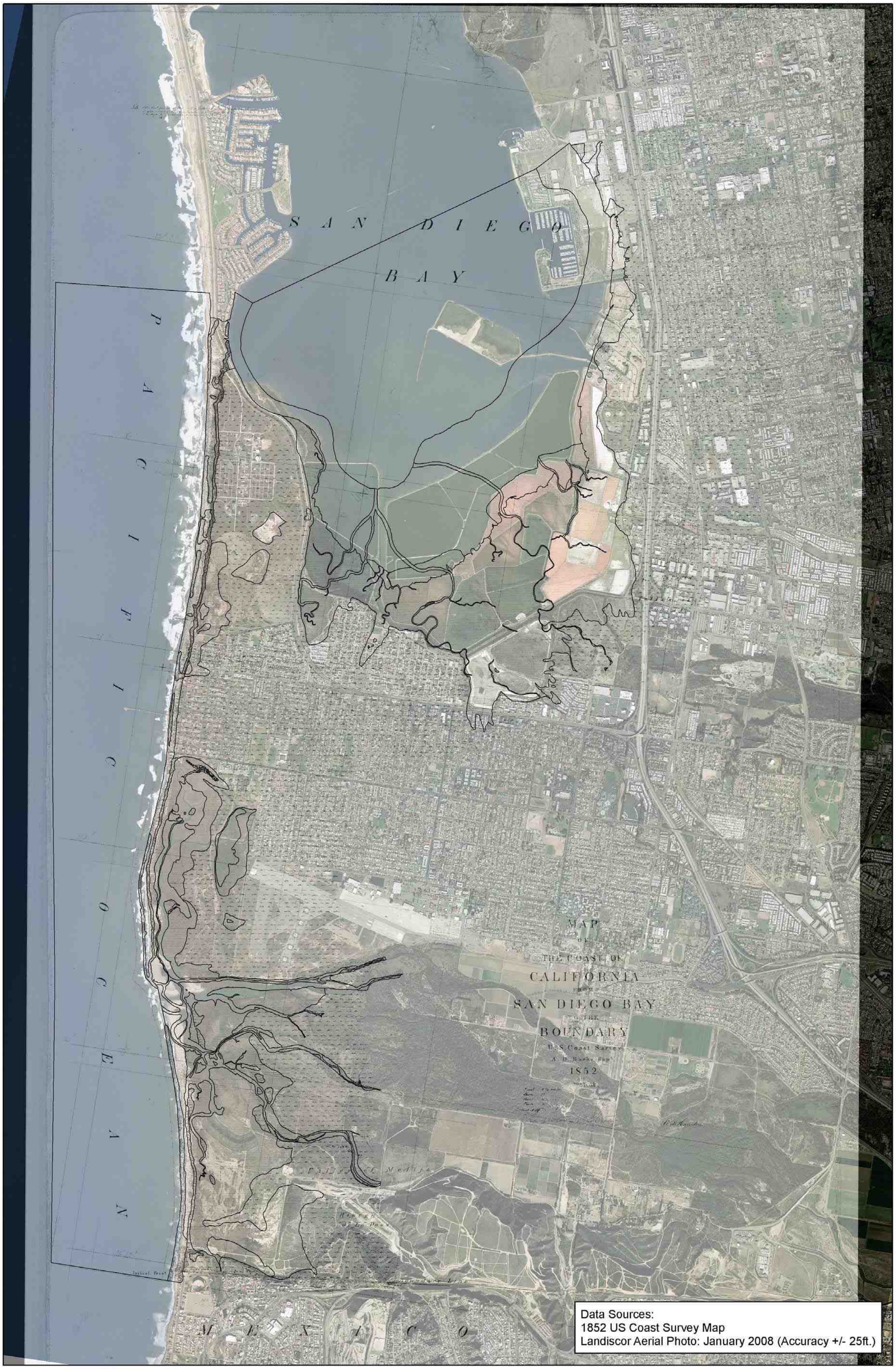


FIGURE 2-7 1852 Map Overlain on Aerial Photograph of South San Diego Bay and Tijuana Estuary

FIGURE 2-8 **1852 Map Overlain on Aerial Photograph of the Project Area**

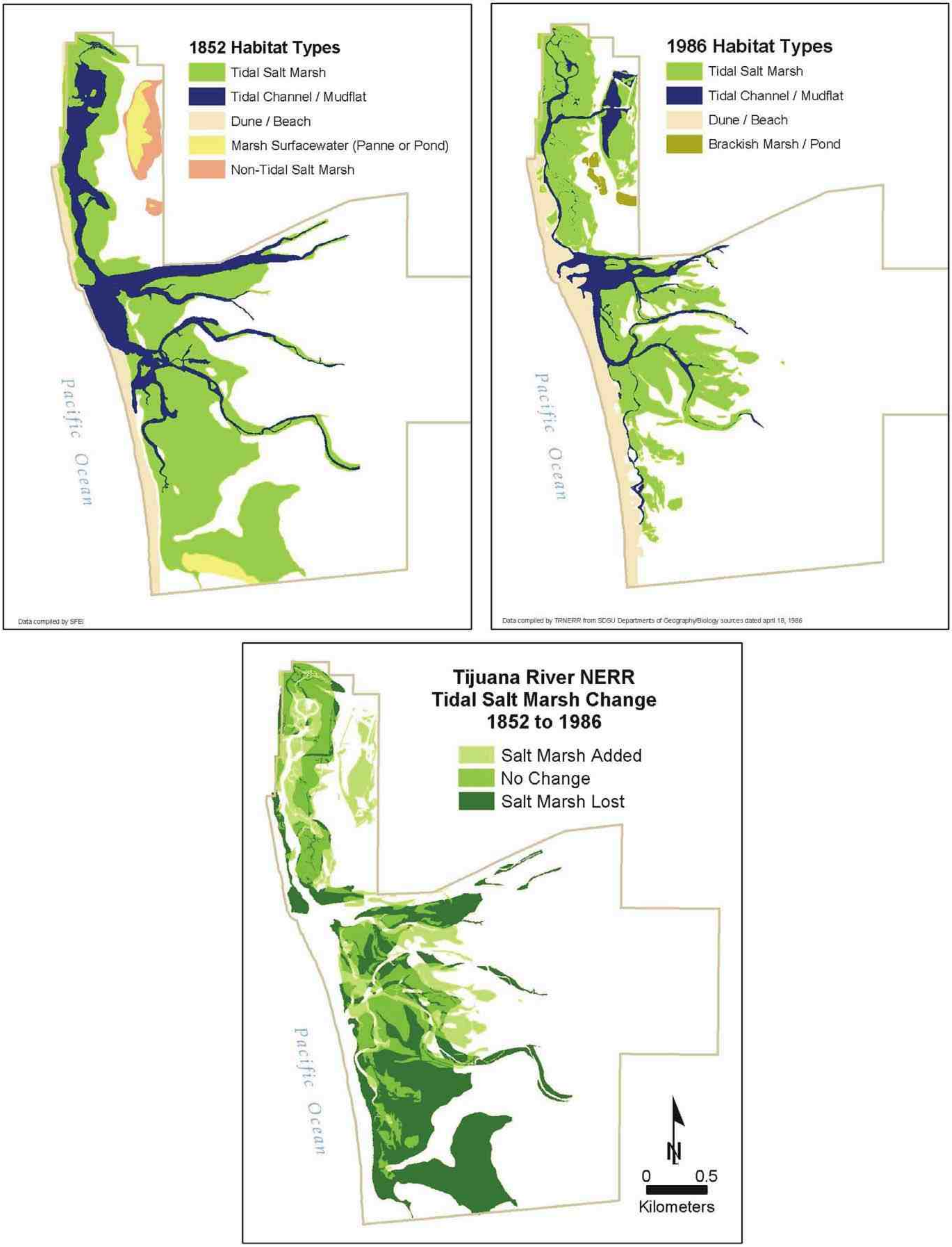


FIGURE 2-9 **1852 Map and 1986 Map of Tijuana Estuary**

of tidal marsh and the corresponding increase in transition/upland habitats. In the northern arm of the estuary, what was formerly mudflat has been colonized with salt marsh resulting in an increase of marshland and a corresponding loss of mudflat. In the southern arm, salt marsh habitat has been lost to upland habitats. The effects of sedimentation on the system are evident, with tidal channels terminating far westward of their 1852 counterparts. Based on these maps, tidal channels and salt marsh in 1986 occupied approximately 2/3 the area they did in 1852, despite the increase in salt marsh in the north arm. The history of disturbance of the south arm of the estuary is presented later in this section. The habitats and biological resources of the project area in 2004 and 2005 are presented in Section 7.0 Biological Resources.

2.3 Geomorphic Setting

The geologic history and geomorphic evolution of Tijuana Estuary have an important bearing on proposed restoration activities. Knowledge of how the estuary formed and continues to evolve is essential to planning of a restoration program within a geomorphic framework. A detailed discussion of the geologic history of the estuary is presented in Zedler and Nordby (1986) while its present geomorphic evolution is presented in Williams and Swanson (1987). These studies and the sources cited therein are summarized here.

The geologic history of the California coast may be characterized as "Active techtonics associated with regional strike-slip faulting…" (Bloom 1983a,b, as cited in Zedler and Nordby 1986). These geologic forces resulted in the formation of a steeply inclined coast with vertically active terraces. In the Holocene period, rising sea levels reclaimed the exposed margins of the coastal shelf. For approximately the last 15,000 years, much of the California coast became submerged as the glacial period ended. Rivers, such as the ancient Tijuana River, were drowned and lagoons formed as longshore drift created sandy barriers along the coast. With flooding, most of the coastal embayments filled with sediment. Lacking continuous flow and scour, the tidal inlets closed between flood seasons.

According to Williams and Swanson (1987), the recent geomorphic evolution of the present day Tijuana Estuary began about 12,000 years ago at the end of the last ice age. At that time, rapidly rising sea level probably drowned the Tijuana River Valley and transformed it into a coastal lagoon. Williams and Swanson theorize that between 5,000 and 12,000 years ago, sea level rise was approximately 5 feet per century. About 5,000 years ago, sea level rise slowed to about 0.6 feet per century and the Tijuana River delta began to advance into the lagoon, and convert it to a riverine floodplain. This advance was the result of sediment deposition during large floods, which resulted in a shifting river course. The mouths of the old river channels became tidal channels until the river course shifted back. Meanwhile, the Tijuana River delta continued to advance into the lagoon until the central portion was filled, leaving the north and south arms and three remnant river channels.

Sea level continues to be a factor in shaping Tijuana Estuary and other coastal bays and lagoons. Rising sea level threatens to once again drown the intertidal systems of the present day. However, currently, human development prevents these systems from gradually shifting inland.

The effects of projected sea level rise on the proposed restoration project are presented in detail in Section 5.0 Coastal Processes.

Tijuana Estuary is constantly evolving in response to the physical influence of wind, waves and stream flow. From season to season, the competing forces of sedimentation and scour shape the estuary. During flood periods, the mouth of the river is scoured, becoming deeper and wider and capable of tidal exchange with less resistance. However, during dry periods, the mouth is subject to sedimentation and the inlet becomes shallow and narrow. Sills or shoals may develop that dampen the tidal exchange, especially during relatively low high tides. A historical review of the morphologic history of the estuary (PWA 1991) suggests that the estuary has been steadily decreasing in size as a result of landward migration of the barrier beach and encroachment of the river delta.

One of the key analyses required for this feasibility and design study was the re-examination of the geomorphic evolution of the southern arm of Tijuana Estuary. This analysis is presented in Section 5.0 Coastal Processes.

2.4 Climate

The coastal climate of southern California has been compared to the Mediterranean region of Europe with cool, wet winters and warm, dry summers. The coastal vegetation is similar to that of southern France, southern Africa and southwestern Australia. This similarity is based on the timing and amounts of rainfall and river flows, rather than average rainfall. In southern California, more than 90% of the mean annual precipitation occurs during a six-month period between November and April. It is a climate of extremes, with years or decades of persistent drought sometimes followed by years with torrential floods. It has often been said that there is no "normal" year, in terms of precipitation, for the region. Rather, cycles of wet and dry years are evident in analyses of annual rainfall in the San Diego area (Zedler and Nordby 1986).

Rainfall data for the San Diego area cited by Zedler and Nordby (1986) extend back to 1880 and reveal a pattern of relative drought interrupted by wet years in 1883, 1921, 1940, 1951, 1978, 1980 and 1983. More recently, the 2004 – 2005 rainy season produced the second highest rainfall total in San Diego history. Rainfall patterns varied greatly during wet years with summer storms in some years and winter drought in others. The factors most important to the estuary are not necessarily rainfall totals but the amount and timing of rainfall and stream flow. Williams and Swanson (1987) cite seven major flood events between 1852 and 1986 that helped shape the current Tijuana Estuary. As described previously, it was primarily during these storms that sediment deposits filled approximately 200 acres of wetland, creating the Tijuana River delta.

2.5 History of Disturbance

Because it is important to illustrate the changes that have resulted in the need for large-scale restoration, a brief history of land use and disturbance in the area is presented. Much of the land in project area was farmed and later abandoned. A 1953 black-and-white aerial photograph (Figure 2-10) shows active farming within the central and southern estuary. Cultivated fields are shown very near the coast, suggesting that the ground water was close to the surface and

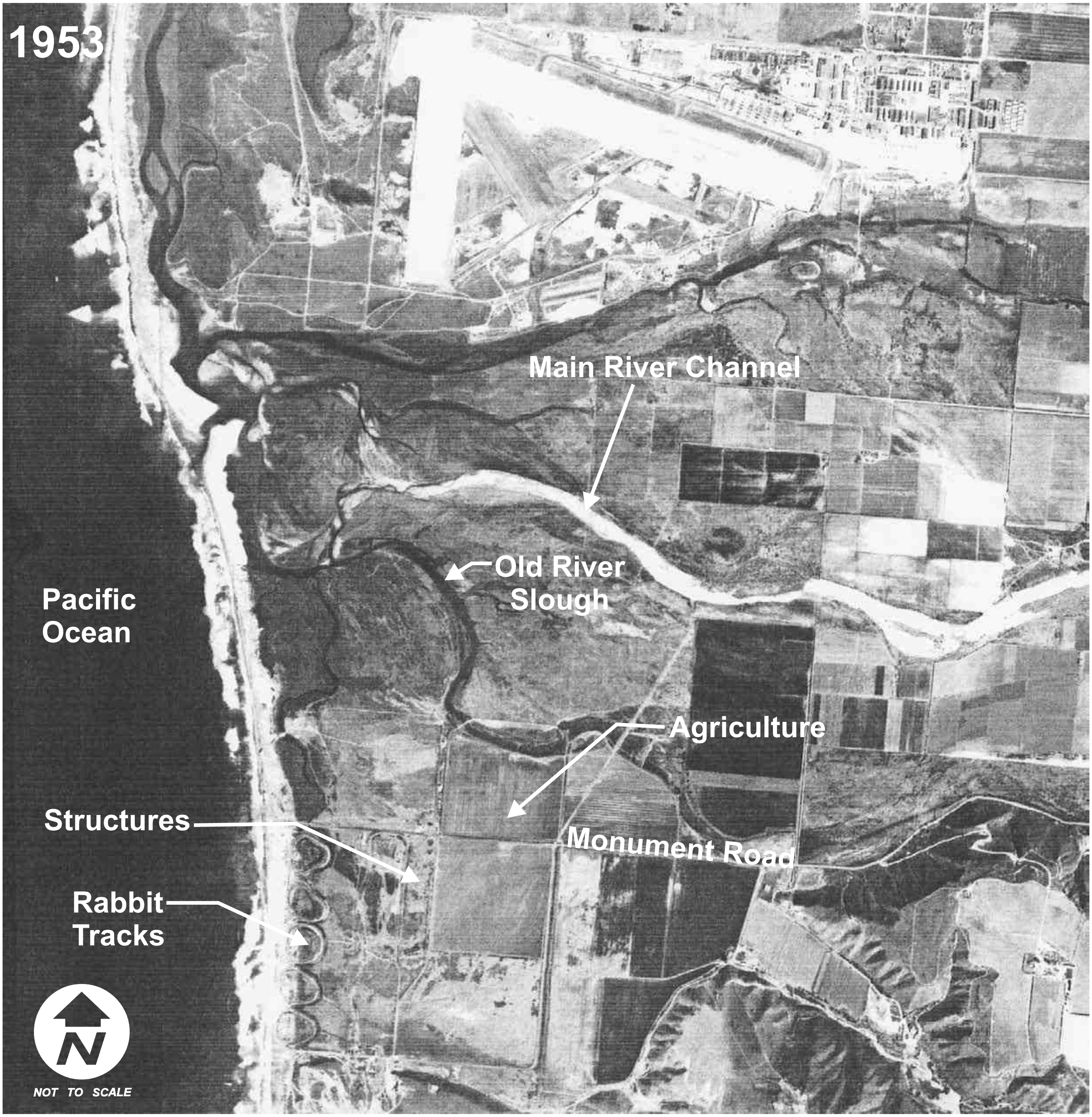


FIGURE 2-10 1953 Aerial Photograph of Tijuana Estuary

relatively fresh, and that seawater had not intruded far inland. The Tijuana River appears to be active in the center of the river valley as evidenced by sand deposition, as opposed to major channels located on the north and south ends of the valley. More recently, the water table in the project area has fluctuated from within a few feet of the surface with salinities of 1–2 parts per thousand (ppt) in 1986-1987 (C. Nordby, unpublished data) to more than 15 feet below the ground surface with salinities of more than 38 ppt in 2002 (Tierra 2002). Currently, large-scale agricultural uses are confined to the extreme eastern end of the Tijuana River Valley.

Military activity was also evident within the estuary in 1953 (Figure 2-10). The U.S. Navy began acquiring Border Field property in the 1930s for use as an auxiliary aviation field. During World War II, the Navy utilized approximately 100 acres as the Naval Operating Base Border Field, which was administered from nearby Ream Field (Tierra 1999). During the 1940s, the project area was used as an aircraft gunnery range, machine gun training center, bombing target, air-to-air gunnery field, and emergency landing field. By 1944, 35 buildings existed in the project area including barracks, mess halls, galleys, and support buildings to accommodate 90 enlisted men and six officers. These structures can be seen in the 1953 aerial along a north/south road at the western edge of the agricultural fields (Figure 2-6). Former military use is also evidenced by a series of roughly circular areas located in the southwest corner of the project area. In historical accounts of Border Field, in particular the *History of Border Field State Beach* (Donald W. Nicol, State Historian, as cited in Tierra 1999) these areas are alluded to as "rabbit tracks:"

> "Pilot gunnery practice was given with steam driven targets that dashed about among the dunes on rails called 'rabbit tracks'. Air to air gunnery practice was held using unmanned airplanes until the 1950s when a riddled plane crashed into a barn and killed several race horses."

In 1961, Border Field was deactivated and was turned over to the Navy Electronics Laboratory that conducted experiments there. In 1971, the facility was transferred to the State of California and the buildings were subsequently razed.

By 1966, a racetrack for rehabilitating horses had been constructed and a number of buildings are shown just west of the oval and near what is now the lower parking lot for Border Field Mesa (Figure 2-11). It is assumed that these buildings were associated with the racetrack as they are still visible in the 1973 aerial (Figure 2-12), two years after the property was transferred to the State of California. The circular military training features appear to have fallen into disrepair, with their seaward sides eroded by the tide. The 1973 photograph also illustrates the amount of disturbance to the project area caused by the various land uses and vehicle access.

2.5.1 Sedimentation at Tijuana Estuary

Accretion of sediment within the tidal channels and marsh plain of the estuary has resulted in the degradation of wetland habitats, leading to conversion to non-wetland habitats. This phenomenon has been recognized as a threat to all San Diego coastal lagoons and estuaries in general, and to Tijuana Estuary in particular (Zedler et al. 1992; CONCUR 2000). Over the past several decades, sedimentation in the south end of the estuary, primarily from Goat Canyon, has

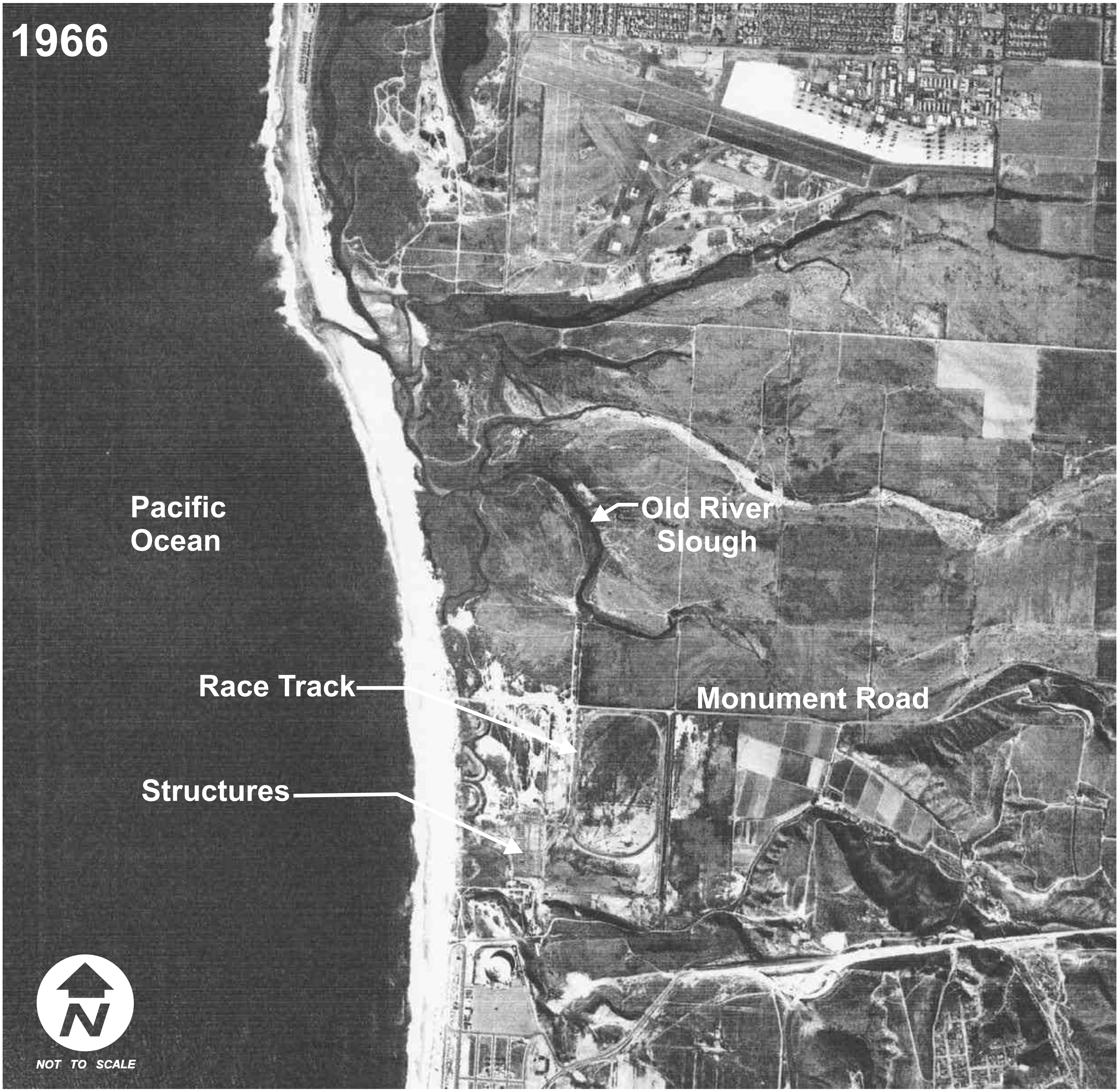


FIGURE 2-11 1966 Aerial Photograph of Tijuana Estuary

FIGURE 2-12 1973 Aerial Photograph of Tijuana Estuary

degraded existing habitat values, encouraged exotic species colonization, and has filled estuarine channels further reducing tidal influence. In 1998 the California State Coastal Conservancy in association with California State Parks and the U.S. Environmental Protection Agency began investigating methods of controlling sediment input via Goat Canyon. These investigations culminated in the construction of sediment retention basins below Goat Canyon, constructed in 2004-2005. While these basins capture and remove new sediment entering the estuary, a considerable amount of sediment remains within the system that may be transported to wetlands and channels during rainfall and associated run-off. Until all sediment from Goat Canyon is captured and removed, and all available sediment within the system has been transported to the nearshore environment, wetland habitats in the southern end of the estuary are likely to experience further impacts.

2.5.2 Sedimentation in the Project Area

Historically, Goat Canyon Creek flowed north across the U.S./Mexico border, southwest around Spooner's Mesa, then to the west where it often terminated in seasonal wetlands abutting Lichty Mesa (Figure 2-13). Over the past 20-30 years, uncontrolled development in the Mexican portion of the watershed has resulted in destabilization of the highly erodible soils of the canyons cut by this creek. As a result, sediment has filled the historic channel of the creek. Prior to construction of the sedimentation basins, the creek overflowed its channel following only moderate rainfall and deposited sediments over a large area of adjacent uplands and wetlands. In 1969 and 1986, the creek deviated from its historic channel, flowing westward across Monument Road, and then directly into the project area (PWA 2000). In 1977 and 1993, the creek's course deviated to the northwest, again crossing Monument Road, and entered existing marshland and tidal channels. The results of these events are described below and demonstrated pictorially in Figures 2-13 through 2-17.

Sediment deposited by creek migrations to the west buried Monument Road and have impacted the salt marsh/salt panne habitat west of the road. In addition, seeds of exotic plant species, in particular non-native grasses and crown daisies, have been introduced to the disturbed landscape. As a result, habitat that was once considered valuable seasonal wetland has become both elevated and degraded. PWA (2000) shows the accumulated sediment in the Goat Canyon alluvial deltas and their extension into the marsh habitat to the west (Figure 2-14). In addition, they illustrate the growth and migration of those alluvial fans to the west (Figure 2-15). An aerial photograph of the project area in 1993 shows the deposition of (light brown) Goat Canyon sediments in the project area (Figure 2-16).

Sediment deposition to the northwest across Monument Road has resulted in similar impacts. The alluvial fan deposited at the end of Goat Canyon has extended across Monument Road resulting in deposition in Old River Slough and associated intertidal wetlands. This deposition has effectively filled Old River Slough in the project area, reducing tidal exchange to a fraction of its former capacity. From 1985 to 1990, the Pacific Estuarine Research Laboratory (PERL) of San Diego State University operated on approximately 70 acres of abandoned agricultural land in the project area (Figure 2-17). The research laboratory drew brackish water from a shallow pond excavated within Old River Slough. Water was pumped from the shallow pond on high tides and stored in a constructed basin for later use in constructed wetlands and experiments. Today there

FIGURE 2-13 Historic Migration of Goat Canyon Creek, 1969 to 1993

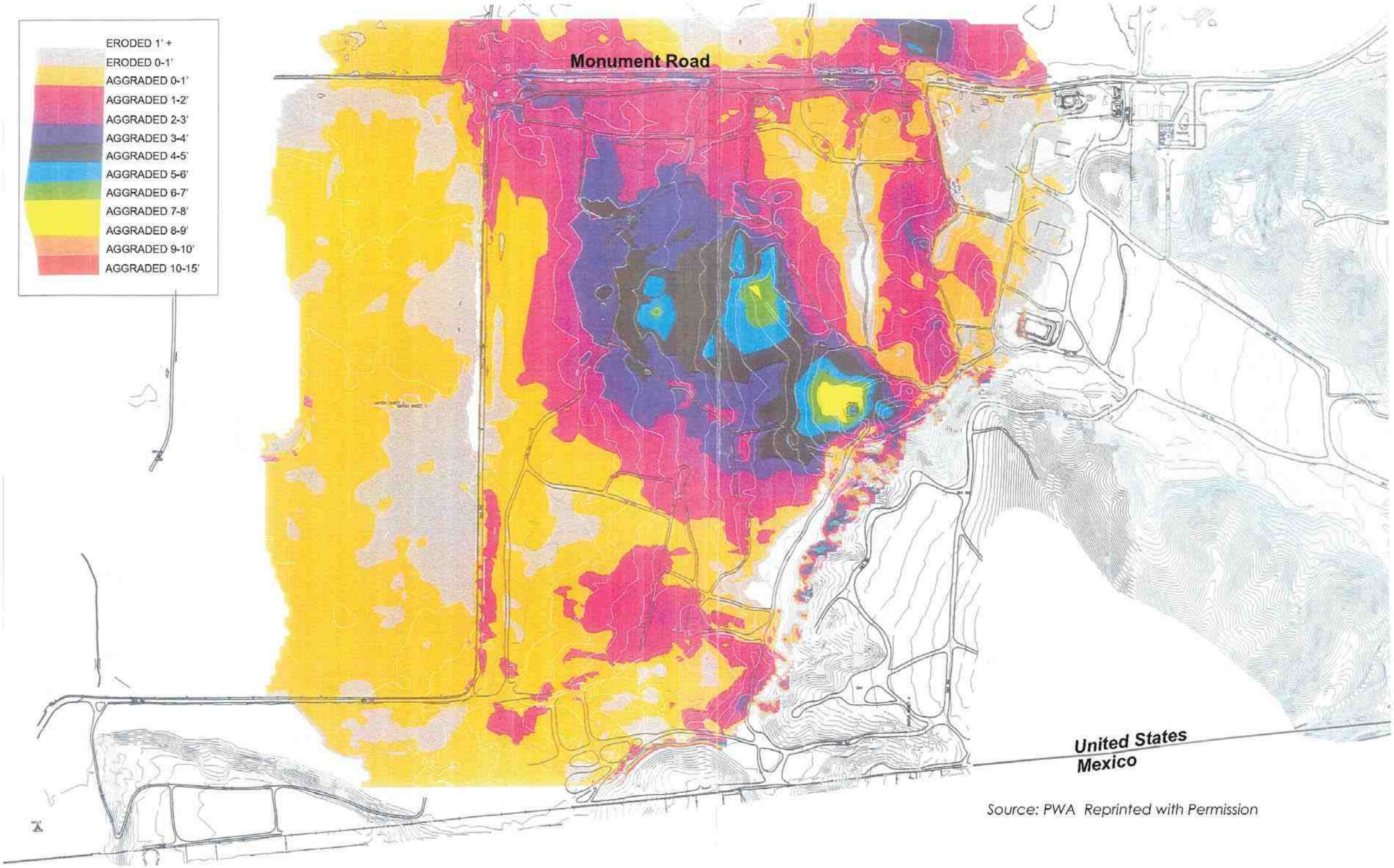
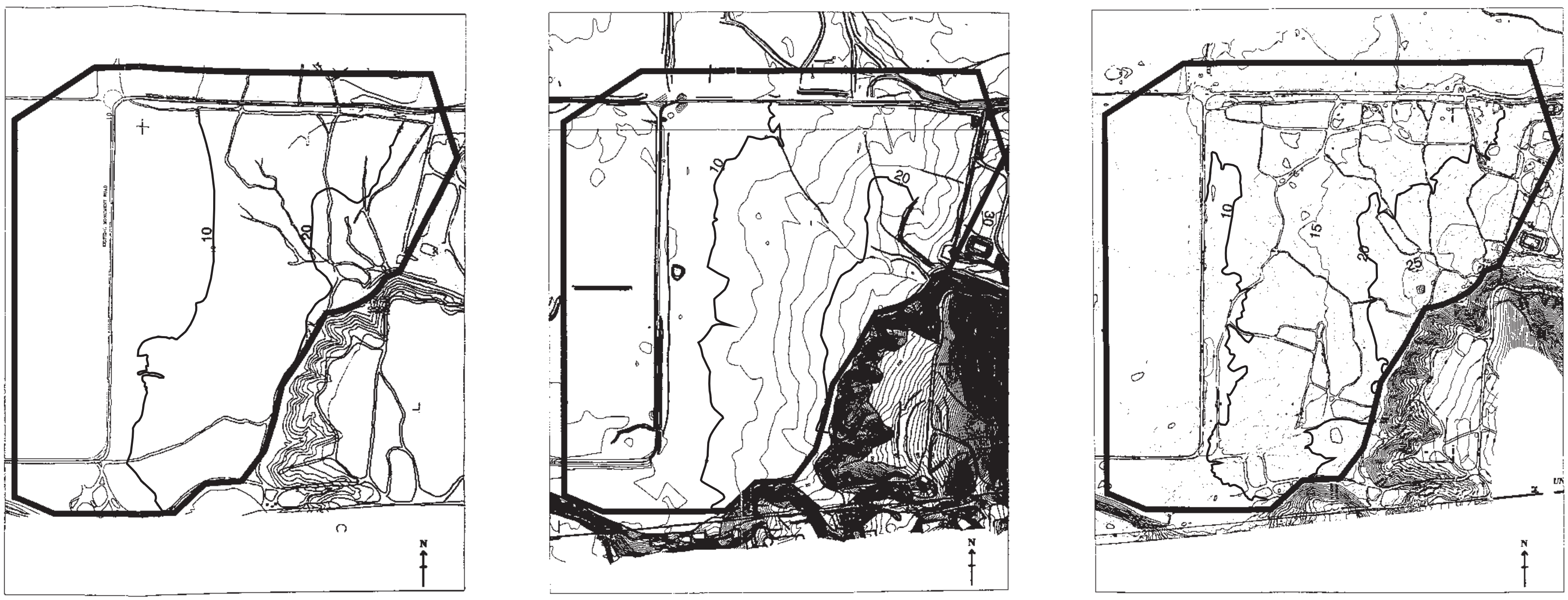


FIGURE 2-14 **Extent of Sediment Deposition from Goat Canyon Creek, 2000**



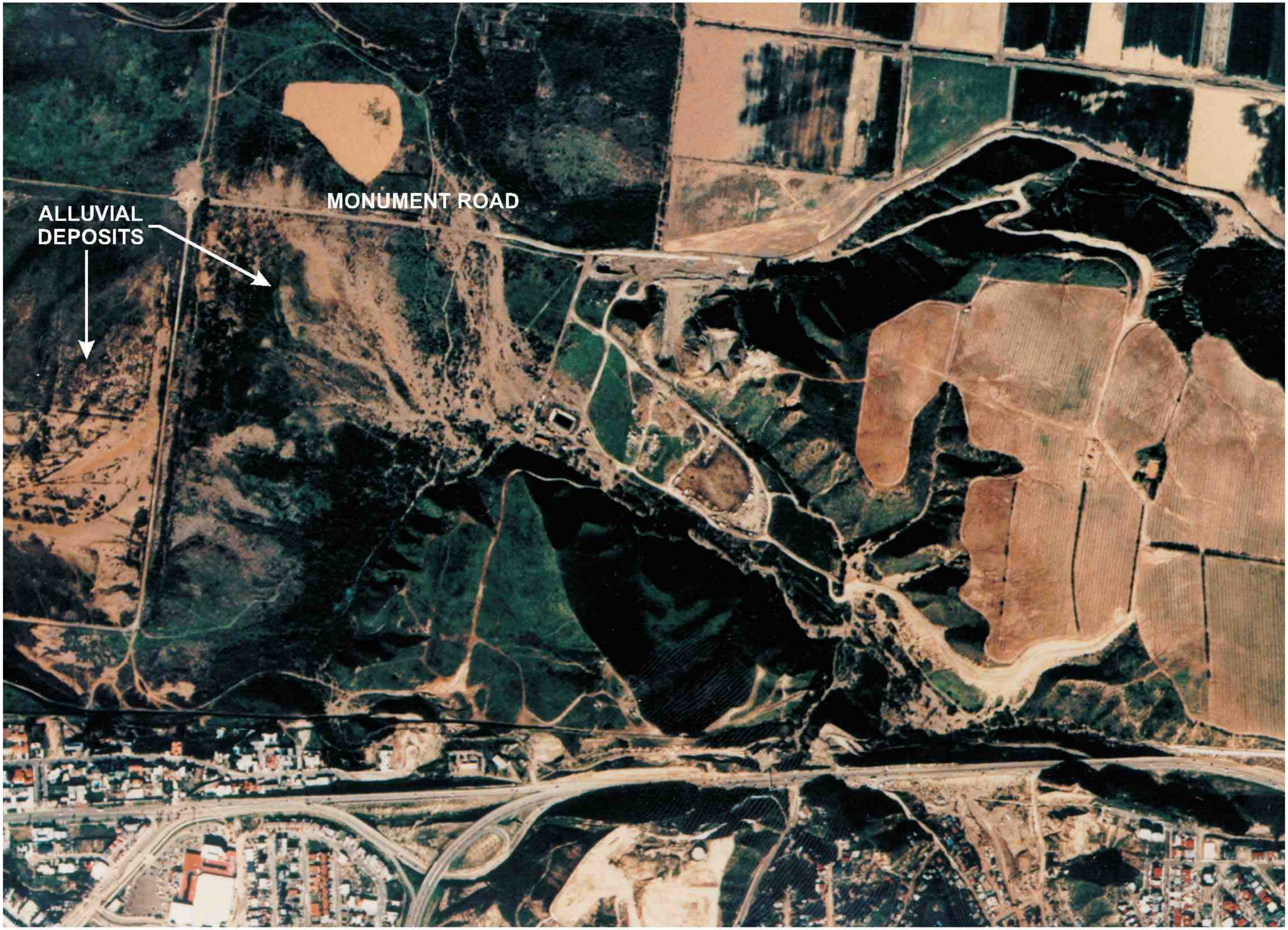
1986

1992

1998

Source: PWA Reprinted with Permission

FIGURE 2-15 Evolution of Sediment Deposits from Goat Canyon Creek, 1986 to 1998



Source: *Rick Engineering*

FIGURE 2-16 **Extent of Sediment Deposition from Goat Canyon Creek, 1993**

FIGURE 2-17 1986 Aerial Photograph of Tijuana Estuary

is no evidence of the shallow pond and that portion of Old River Slough is no longer tidal (C. Nordby, pers. obs.).

Because of the reduced tidal flow in Old River Slough, the location of the 20-acre Model Marsh was changed during the planning phase of this restoration component**.** Originally, the Model Marsh was to be located at a site along a curve in Old River Slough shown in Figure 2-17.

However, in the late 1990s, sediment deposition in the slough clearly indicated that constructing the marsh at this site would entail an unacceptable risk of failure. What was once a channel approximately 10 to 12 feet wide and 1 to 2 feet deep was reduced to a channel approximately 3 feet in width and only inches in depth at high tide (C. Nordby, pers. obs.). In order to ensure a greater level of success, the project was moved to its current location and a small berm was constructed around the perimeter to protect it from sediment conveyed by Goat Canyon Creek.

2.5.3 Construction of Sedimentation Basins

Sedimentation from Goat Canyon has long been recognized as a threat to the long-term viability of the wetland habitats in the southern end of the estuary. Construction of sediment detention basins to capture this sediment began in the fall of 2004 (Figure 2-18). The project was approximately 50% completed when construction was halted in March 2004 for the breeding season of sensitive bird species, as mandated by a Biological Opinion rendered by the USFWS pursuant to Section 7 of the federal Endangered Species Act. Construction resumed in September 2004. Unfortunately, heavy rainfall in October 2004 filled the basins with sediment prior to their completion. Much of the sediment from the October rains was subsequently removed and construction resumed in November of 2004. However, additional rains in November and December filled the basins with sediment once again. This sediment had not been removed when record level rains occurred in mid-January of 2005. Because the basins were already full, sediment passed through the basins and was deposited on the disturbed salt marsh/salt panne habitat located to the west (Figure 2-19). This single event resulted in the burial of approximately 15 acres of salt marsh/salt panne under as much as 2 feet of sediment. Additional area was buried during another storm on January 28-29, 2005, which produced approximately 1 inch of rainfall.

The previously described events illustrate the difficulty in controlling sediment in a binational estuary. Mexican authorities have allowed massive clearing of the hillsides located within the Goat Canyon watershed immediately south of the U.S/Mexico border (Figure 2-20). To date, efforts to control this sediment source have not been successful. Until the problem is addressed at its source, such instability within the watershed will continue to impede restoration efforts on the U.S. side of the border.

2.5.4 Impact of Sedimentation in the Project Vicinity

Loss of tidal prism in the channels of the project area has been documented in other studies of the area including the TETRP EIR/EIS, ENTRIX et al. 1991) and the Goat Canyon/ Cañon de los Laurels Enhancement Plan (SWIA et al. 1999). A review of historical aerial photographs illustrates this loss and the rapidity with which it occurred.

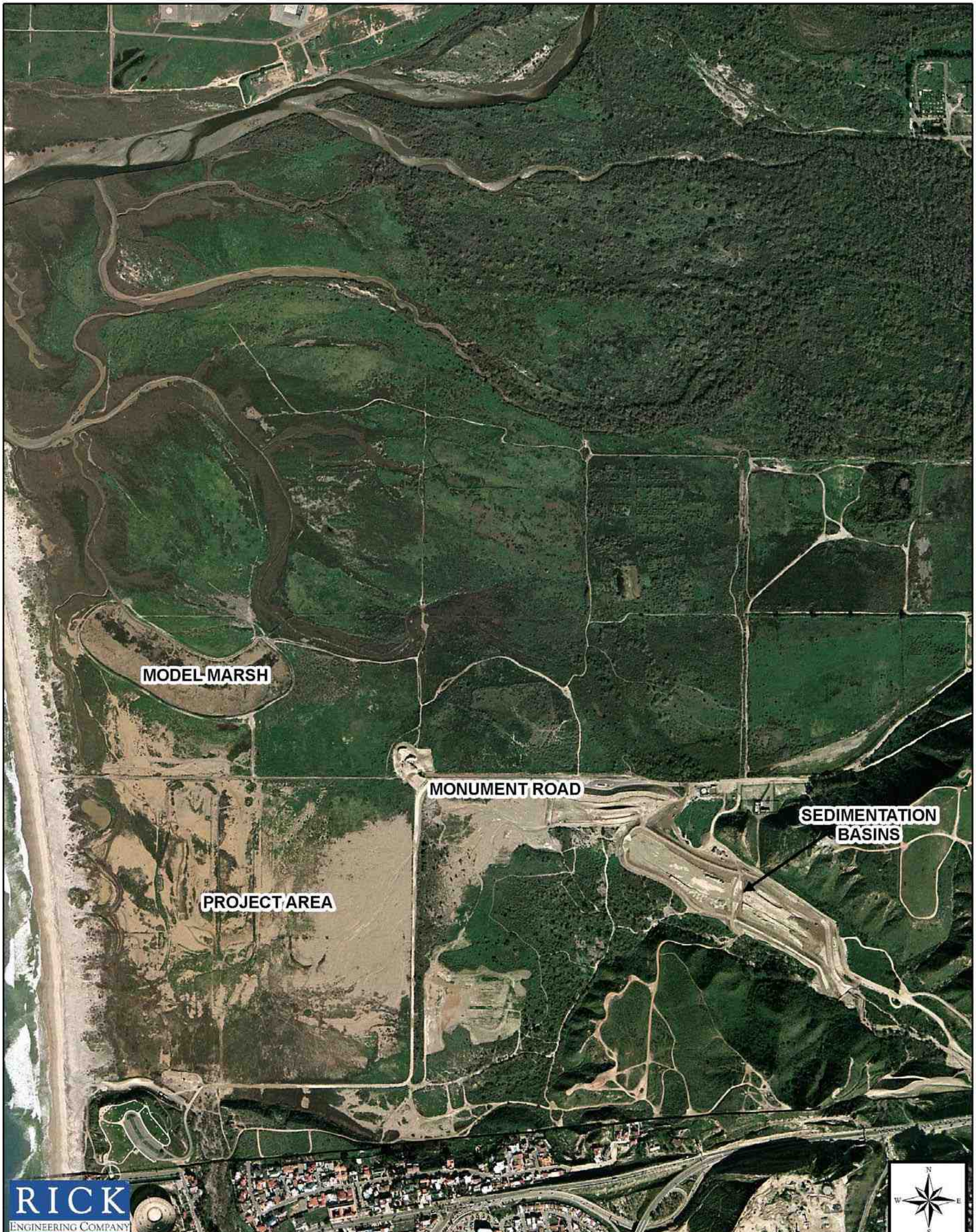


FIGURE 2-18 **Goat Canyon Sediment Retention Basins**

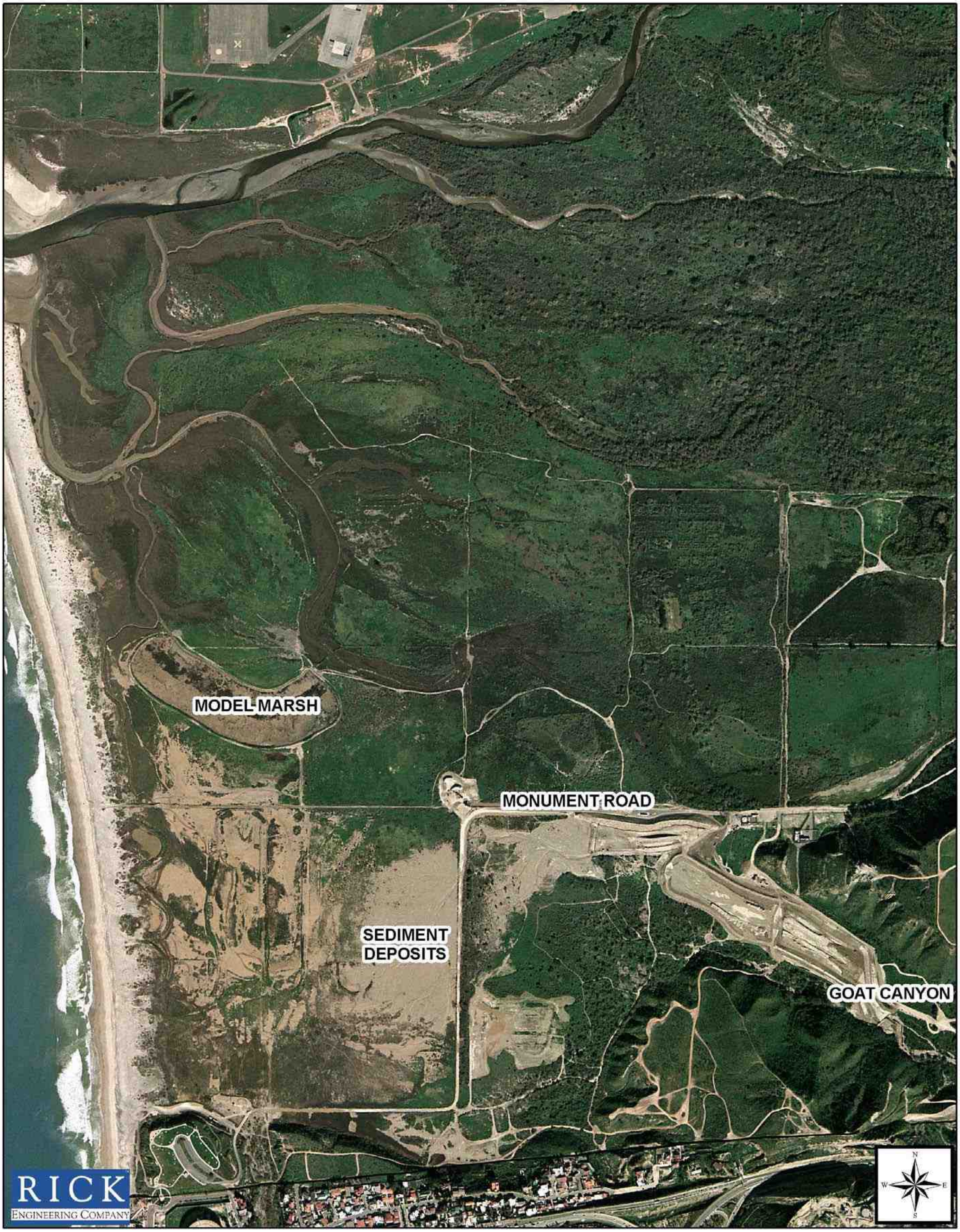


FIGURE 2-19 **Sediment Deposition, 2004 to 2005**

FIGURE 2-20 Clearing on Slopes within Tijuana, Mexico

Aerial photographs from 1973 and 1978 (Figures 2-12 and 2-21) depict a narrow embayment or a wide channel just south of the tidal inlet as well as broad channels associated with Old River Slough, Mid-Slough and South Beach Slough. The 1978 photograph (Figure 2-21) appears to have been taken at or near high tide illustrating the amount of open water relative to mudflat or salt marsh. The Old River Slough channel is obvious, continuing as a wide channel east of the project area.

By 1986, the results of sedimentation in the south arm of the estuary are evident. The embayment south of the inlet has filled with sediment and has been colonized by salt marsh plants (Figure 2-22). Similar evidence of sedimentation is apparent in the Old River Slough with open water area confined to a narrow channel bordered by mudflat. In addition, the eastern extent of Old River Slough has been substantially reduced with little open water area east of the Border Field State Park kiosk.

By 1995, the sediments deposited in the embayment south of the inlet and in the Old River Slough channel had been further colonized by salt marsh plants, primarily pickleweed (*Salicornia virginica*) (Figure 2-23). The Old River Slough channel is much reduced at the original site proposed for construction of the Model Marsh, which led to the decision to move it to its present location. By 2004, the channel of the Old River Slough is nearly completely colonized by pickleweed with very little open water (Figure 2-24). The Model Marsh is obvious and its hydraulic connection with South Beach Slough has scoured and deepened that tidal channel. Other channels, including Mid River Slough, show similar effects of sediment deposition and colonization by pickleweed.

2.6 Summary

The project area, defined as the south arm of Tijuana Estuary from approximately Old River Slough southward to the southern extreme of Monument Road, has been heavily impacted by human land use activities. The channels of the southern estuary have been filled with sediment from Goat Canyon and other sources and have lost much of their tidal prism. Areas that were formerly seasonal wetlands and salt pannes have been buried by sediment and are now succeeding to disturbed upland habitats. Pickleweed, an aggressive colonizer, dominates the salt marsh to the exclusion of less aggressive species. The beach has retreated eastward, obliterating the circular gunnery tracks in the south end, yet has not retreated to the degree predicted by PWA (ENTRIX et al. 1991).

Without active restoration of both tidal prism and associated habitats, this trend will continue until the south end of the estuary is no longer a functioning intertidal salt marsh. Once the remaining tidal influence is lost, the organisms that depend on diurnal flushing in a healthy intertidal wetland will disappear, leaving a high marsh dominated by one or two species - primarily common pickleweed and glasswort (*Salicornia subterminalis*). Only by actively reclaiming what has been lost over decades of filling, diking and sedimentation, can the southern portion of Tijuana Estuary survive in the long term.

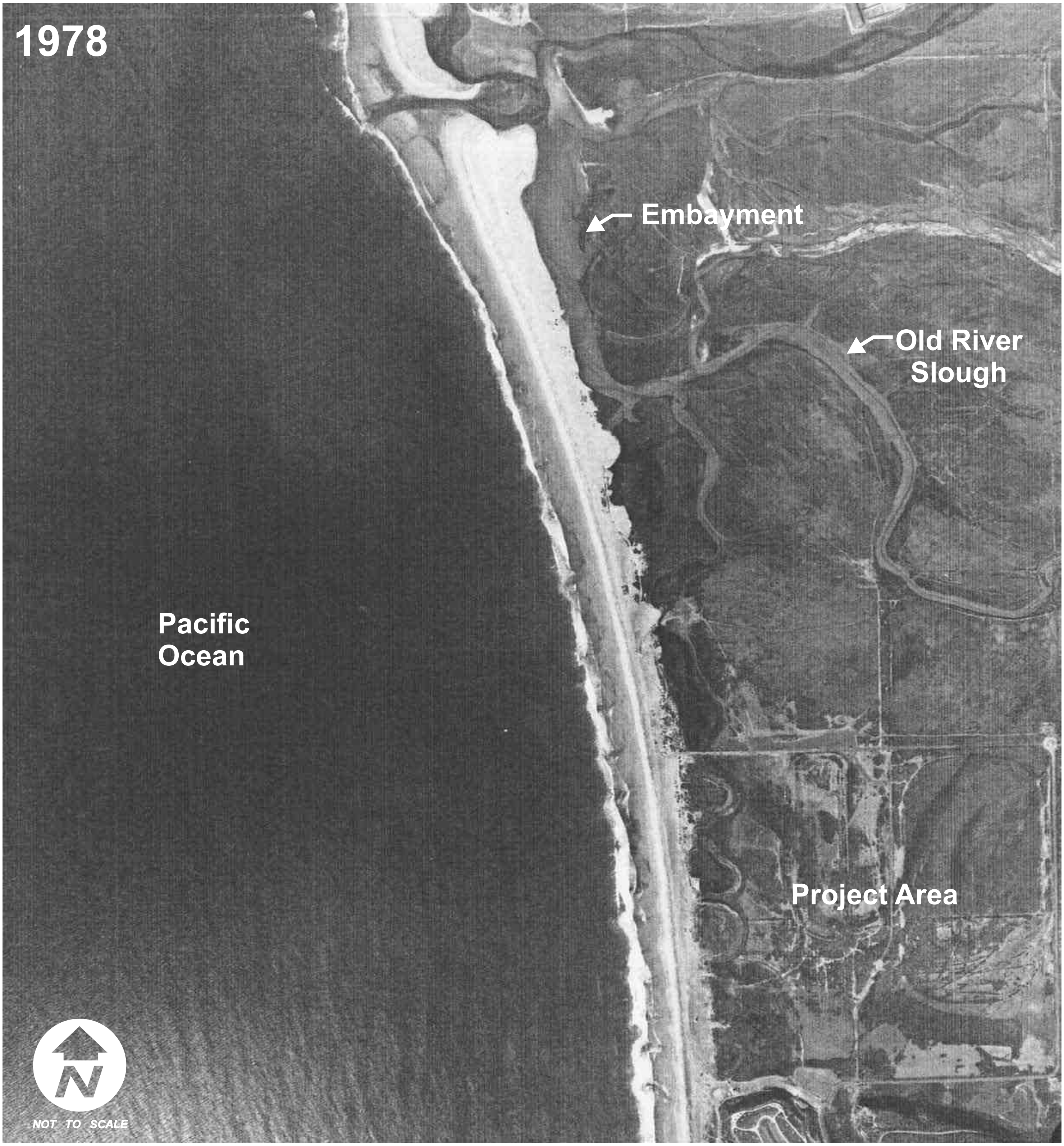


FIGURE 2-21 1978 Aerial Photograph of Tijuana Estuary

FIGURE 2-22 Old River Slough and South Estuary, 1986

FIGURE 2-23 Old River Slough, 1995

FIGURE 2-24 Old River Slough, 2004

3.0 RESTORATION GOALS

The primary goal of the Tijuana Estuary - Friendship Marsh Restoration Feasibility and Design Study is to restore, to as near natural conditions as possible, the southern portion of the estuary. This part of the estuary has been subjected to degradation as a result of human land uses. The need for a restoration program was first noted in the Tijuana Estuary National Estuarine Sanctuary Management Plan (James Dobbin Associates, 1986). The management plan identified a number of management objectives to support the overall goal of restoration. These were adopted for the 1991 Tijuana Estuary Tidal Restoration Program and were reaffirmed by project Technical Advisory Committee (TAC) and the Tijuana River Estuary Research Reserve Research and Restoration Committee with minor adjustments. These objectives are presented below.

- Restore tidal prism approximately to the size that existed under natural conditions (in order to minimize inlet closure).
- Restore the functioning of the tidal hydrodynamic system to a state similar to that which existed under natural conditions.
- Allow for continued functioning of a tidal hydrodynamic system with future anticipated geometric changes: including sea level rise, migration of the barrier beach, and changing river channel locations.
- Restore dune vegetation to minimize future loss of wetland area resulting from inland migration of the barrier beach.
- Minimize future loss of restored and existing wetland area resulting from Tijuana River sedimentation.
- Minimize future loss of restored or existing wetland area resulting from Goat Canyon sedimentation.
- Restore, to the maximum extent possible, areas of former salt marsh affected by sedimentation.
- Restore, to the maximum extent possible, areas of former mudflat affected by sedimentation.
- Minimize the disturbance of marsh plain areas in the north arm of the estuary.
- Minimize the potential year-round reduction in salinity in the marsh plain and intertidal areas due to wastewater flows, while preserving the short term salinity lowering effect of flood flows in winter.
- Minimize trampling of the barrier beach dune and vegetation by restricting public access.
- Provide the same area of high marsh and transition zone as exists presently.
- Identify existing resources so that a salvage operation can be planned and carried out prior to implementing the enhancement plan.
- Incorporate a phasing program in the enhancement plan.
- Minimize impact on privately owned parcels.
- Protect and enhance endangered species habitat.
- Provide habitat that will help maintain regional biodiversity.

In addition to the goals and objectives adopted by TETRP, the Southern California Wetland Recovery Program (SCWRP), a multi-agency group dedicated to wetland restoration in southern California, has developed a set of regional restoration goals. These include:

- Preserve and restore coastal wetland ecosystems.
- Preserve and restore stream corridors and wetland ecosystems in coastal watersheds.
- Recover native habitat and species diversity.
- Integrate wetlands recovery with other public objectives.
- Promote education and compatible access related to coastal wetlands and watersheds.
- Advance the science of wetlands restoration and management in southern California.

These goals and objectives are compatible with the goals and objectives of the proposed project. However, the project-specific goals and objectives were developed for the Tijuana Estuary – Friendship Marsh Restoration Feasibility and Design Project. After some modification, these were adopted by the TAC and Research and Restoration Committee. The goals developed for this project include restoration targets while the objectives include steps to be taken to achieve those goals.

The original goal of the Tijuana Estuary Tidal Restoration Program (TETRP; ENTRIX et al. 1991) was to restore the estuary's tidal prism based on the historic volume assessed from a U.S. Coastal Geological Survey map produced in 1852. In order to achieve this goal, approximately 500 acres of channels and marsh plain were to be excavated in the southern arm of the estuary and a portion of the spoils used to construct two river training berms to protect the area from damaging river flood flows (Figure 3-1). Though the river training berms were not supported by the regulatory agencies**,** as the project proceeded through the environmental review process, a first phase of the TETRP was approved by the TRNERR Management Authority and adopted by the sponsoring agencies. The task of developing a flood/sediment management design solution for subsequent phases of the restoration program was deferred to the current study. As presented in Section 1.0, first phase projects such as the Oneonta Slough Tidal Connection (1997) and the 20-acre Model Marsh (2000) were implemented.

3.1 Establishing Project Goals and Objectives

There have been many changes to the habitats of the southern arm of the estuary since 1991. For example, sedimentation from Goat Canyon has resulted in the transformation of salt marsh/salt panne habitat into disturbed habitat, has filled areas of former channel converting them to pickleweed-dominated marsh, and has resulted in the loss of substantial acreages of mid- and high salt marsh. Similarly, sediment accretion in the formerly wide-channels/embayment has resulted in the colonization of pickleweed and the associated loss of mudflat habitat. Thus, there has been a clear, yet unquantified, loss of channel, salt marsh/salt panne, mudflat and mid-high salt marsh acreage that may be reversed by implementing actions outlined in this feasibility and design study.

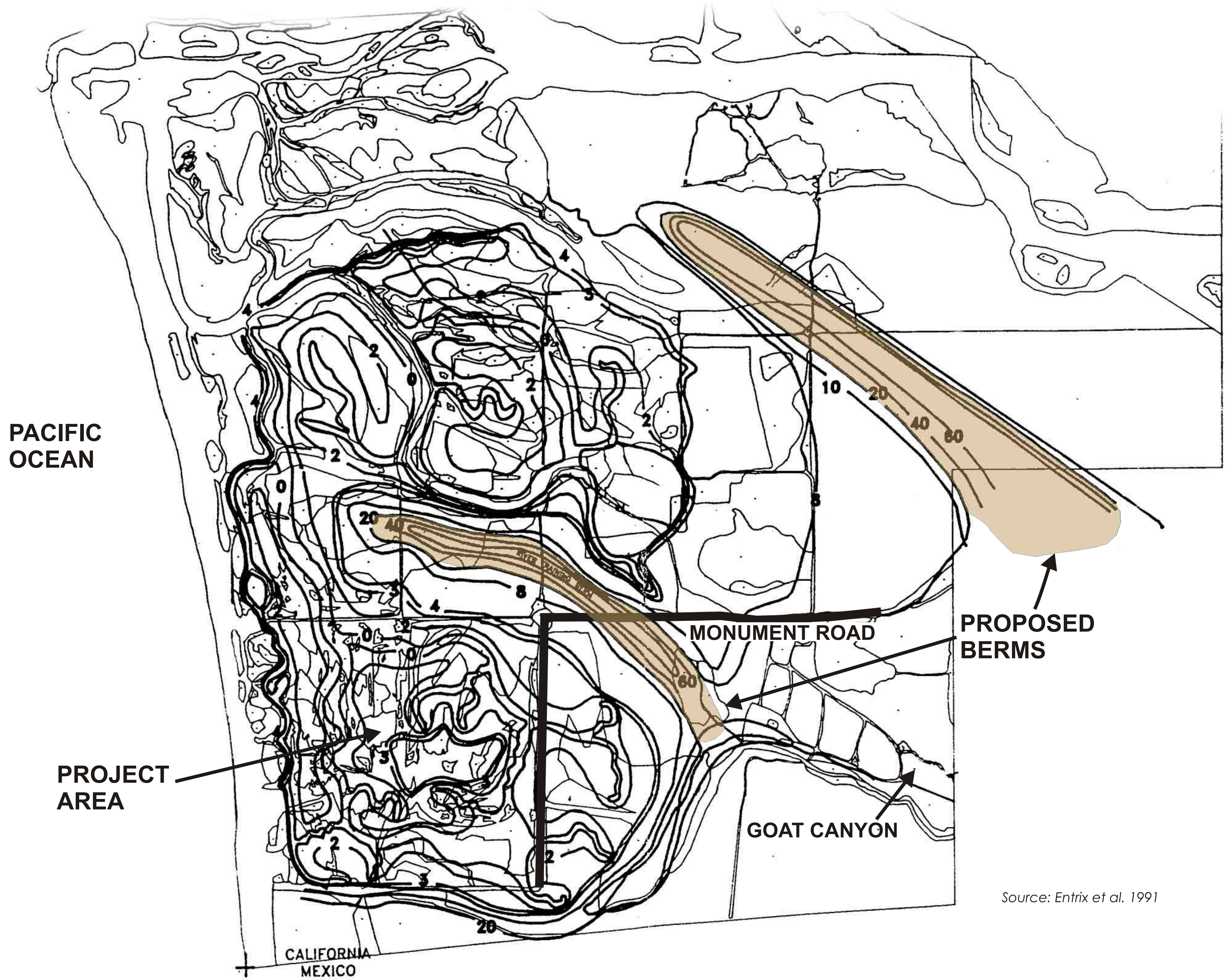


FIGURE 3-1 Proposed River Training Berm Locations, TETRP 1991

In the same fashion, the tidal prism of the estuary has been reduced both recently and historically. In 1987, Phillip Williams & Associates (PWA) estimated that the tidal prism of the estuary was 290 acre-feet. This represents an estimated 80% reduction in tidal exchange as estimated by PWA based solely on the1852 U.S. Coastal Geological Survey map. A similar estimate conducted for this study places the tidal prism at 330 acre feet (see Section 5.0 Coastal Processes). Additional predictions made by PWA, i.e., that the barrier beach would continue to migrate eastward and that migration, combined with sea level rise, would result in mouth closure on a frequent basis, have yet to be realized. Though the mouth of the estuary has remained open and relatively stable in recent years, it is clearly shallow, narrow, and subject to closure as a result of sedimentation associated with extreme events such as high tides and storm waves. Therefore, it was submitted that an increase in tidal prism would be a reasonable goal of this feasibility and design study. This goal, adopted by the combined Technical Advisory Committee and Research and Restoration Committee, is discussed in greater detail below.

The goals of increasing habitat types and tidal prism need not be mutually exclusive. Tidal prism may be increased in a number of ways, including increasing the area of subtidal channel, tidal marsh and marsh plain, and by increasing intertidal mudflat.

Species-based restoration goals can also be meshed with habitat/tidal prism goals. For example, creation of low marsh habitat will benefit light-footed clapper rails, mudflat will benefit rails and shorebirds; intertidal channel habitat will benefit wading bird species; subtidal habitat will benefit aquatic organisms and diving birds, such as California least tern. Given these broad guidelines, the following goals and objectives were developed for the feasibility and design study.

Goal 1. Increase tidal prism.

Objective: More than double the existing tidal prism of the estuary from the current 350 acre-feet to 750 acre-feet by expanding the area of subtidal channel, intertidal salt marsh, and marsh plain in the southern end of the estuary.

The results of hydrologic modeling conducted for this study determined that the overall area of restoration would be less than the 500 acres identified in the 1991 Tijuana Estuary Tidal Restoration Program (ENTRIX et al. 1991) due to the constraints posed by the hydrology of the Tijuana River (see Section 6.0, Tijuana River Flood Hydrology Erosion and Sedimentation). Therefore, the potential for restoring the tidal prism and the area of restored marsh was reduced. As a starting point, it was suggested that the current feasibility study include an area of approximately of 250-300 acres and that a goal of this restoration be to increase tidal prism to approximately 50% - 60% of that estimated from the 1852 map (1,550 acre-feet). Under this scenario, the tidal prism would be increased from approximately 290 acre-feet to 750 acre-feet, assuming the PWA's estimates of the tidal prism in 1852 were accurate. This action would roughly triple the existing tidal prism, following the logic presented in the TETRP plan.

The 1991 TETRP plan called for the restoration of 1,550 acre-feet of tidal prism through the shallow excavation of approximately 5 million cubic yards of sediment in the southern arm of the estuary to recreate tidal channels, mudflats and marshplain. The TETRP plan estimated that the excavation of 5 million cubic yards would increase the area of subtidal habitat from 3 to 90 acres, intertidal mudflat from about 30 to 160 acres, and intertidal salt marsh from 300 to 460 acres. This feasibility and design study recommends similar relative increases in each habitat type, although reduced in scale.

Goal 2. **Restore areas of former salt marsh, tidal channel, and mudflat affected by sedimentation to the maximum extent possible.**

Objective: Restore approximately 250-300 acres of the project area to coastal wetland habitat with roughly 25% restored to tidal channels and ponds, 50% to salt marsh habitat, and 25% to mudflat habitat.

Objective: Of the area to be restored, achieve a habitat mix of approximately 50% low marsh, dominated by cordgrass (*Spartina foliosa*), 25% mid-marsh, dominated by a mosaic of species, and 25% high marsh, dominated by glasswort (*Salicornia subterminalis*).

The high marsh component is included because, at this stage, it appears that there will be project impacts to this habitat type and that it should be replaced in order to maintain habitat for the state-listed endangered Belding's savannah sparrow. Based on the percentages of each habitat type presented above, the following changes in habitat acreage would occur following implementation of a restoration project based on this feasibility and design study.

Restoration Objectives by Habitat Type

Habitat	Existing Area (acres)*	Predicted Area (acres)
Channels and ponds	173	235.5-248
Mudflats	33	95.5-108
Salt marsh/salt panne	439	564.0-589

* Based on Zedler et al. 1992

The salt marsh habitat created would be represented as:

low marsh	63-75.0 acres
mid-marsh	31-37.5 acres
high marsh	31-37.5 acres

Objective: Design restored areas to reduce the potential for shifts in habitat type due to sedimentation by over-excavating some features, such as tidal channels and, in some cases, mudflats and marsh plain.

From observations of the tidal lagoons in the northern arm of the estuary and in the newly created 20-acre Model Marsh, it is anticipated that some areas created as mudflat will accrete sediment and eventually become salt marsh. This feasibility and design study proposes a restoration project that would accommodate this eventual shift in habitat type and presents a maintenance plan to prevent large-scale sediment deposition (see Section 5.0 Coastal Processes Affecting Tijuana Estuary).

Goal 3. Restore barrier beach and dunes.

Objective: Use suitable sediments excavated during the restoration to create subtidal and intertidal habitats to restore the barrier beach and dunes.

Objective: Stabilize the dunes through the removal of invasive species and planting of native species to prevent or reduce dune overwash and eastward migration.

One of the overall goals of the feasibility and design study is to use excavated sediment to create the habitats listed under Goal 2 to restore the barrier beach and dunes. Accordingly, sediment cores have been collected from soil borings at 24 locations and analyzed for grain size with 6 samples analyzed for chemistry. While the results of the grain size analysis indicate a relatively heterogeneous distribution, there are areas of coarse sand that could be placed on the beach. An additional 56 samples were collected from trenches excavated to determine the presence/absence of buried cultural resources in the project area. This analysis is presented in detail in Section 8.0 Substrate Characterization**.**

Goal 4. Increase habitat for endangered species.

Objective: Create between 62.5 and 75 acres of low marsh habitat to support an estimated 16 –19 pairs of the federally listed and state-listed endangered light-footed clapper rail.

Objective: Increase mid- and high marsh by 31–37.5 acres each to provide additional high quality habitat for the state-listed endangered Belding's savannah sparrow, providing habitat for 198-240 pairs.

Objective: Create 62.5-75 acres of channel habitat to provide foraging habitat for California least tern.

Objective: Create 62.5-75 acres of mudflat to provide foraging habitat for clapper rail and shorebirds.

Objective: Create undisturbed transition zone habitat for the recovery of the endangered salt marsh bird's beak and associated species (see Goal 5).

Creation of 62.5-75 acres of low salt marsh habitat will increase the preferred nesting habitat for the federally endangered light-footed clapper rail. A recent survey of the 20-acre Model Marsh yielded 5 pairs of clapper rails. Assuming similar densities in restored low marsh habitat following implementation of the current plan, the restored area could support an additional 16-19 pairs of clapper rail.

Increasing the mid- and high marsh by 31-37.5 acres each would provide additional habitat for the state endangered Belding's savannah sparrow. A 2004 survey of the degraded high marsh located south of the horse trail to the beach and west of Monument Road (the location of most of this proposed restoration) revealed an estimated 147 pairs of this species. However, it should be noted that this area was subjected to a large scale sediment deposition in January 2005, which greatly reduced the number of sparrows (see Section 7.0 Biological Resources, for details). Given that area of approximately 85 acres, roughly 1.72 pairs of Belding's savannah sparrow per acre can be supported by sub-optimal, degraded high marsh habitat. It is assumed that creation of high quality mid-and high marsh habitat would provide habitat for approximately twice that density (62 acres X 3.45 pairs per acre = 214 pairs). Therefore, the potential loss of degraded habitat would be off-set by the creation of higher quality habitat capable of support higher densities of this sensitive species.

Creation of 62.5-75 acres of channel habitat would provide foraging habitat for California least terns, particularly young fledglings who are often taught to forage in calm estuarine waters. Furthermore, the increase in channel habitat will increase food chain support for all predators by increasing the area available for fishes and invertebrates.

Creation of 62.5-75 acres of mudflat habitat would provide foraging habitat for the federally listed and state-listed endangered light-footed clapper rail and other shorebirds.

Goal 5. Increase area of undisturbed transition zone.

Objective: Expand the area of undisturbed transition zone habitat within the southern end of the estuary by creating a gentle elevational gradient from the landward edge of high salt marsh to provide a buffer between wetlands and uplands, support important insect plant pollinators, provide foraging and high tide refugia for birds, provide areas for the recovery of the federally listed endangered salt marsh bird's beak, and support a unique assemblage of plants and animals.

Transition zone habitats have been recognized as regionally rare and important. They function as a buffer between wetlands and uplands, support important insect plant pollinators, provide foraging habitat for birds, provide habitat for the federally listed endangered salt marsh bird's beak, and support unique assemblages of plants and animals. Transition zone habitats have been encroached upon at Tijuana Estuary and most southern California coastal wetlands. The feasibility and design study offers an opportunity to expand the acreage of transition zone. This can be accomplished by creating a gentle elevational gradient from the landward edge of high salt marsh. The highest salt marsh plants that occur at Tijuana Estuary include saltgrass (*Distichlis spicata*), alkali weed (*Cressa truxillensis*), and alkali heath (*Frankenia salina*).

Goal 6. Incorporate a berm to prevent sudden loss of restored habitat from flood events.

The Tijuana River watershed has the potential to produce destructive floods. It was agreed that the project design should anticipate and be responsive to flooding to prevent either sudden or more gradual loss of restored intertidal sites due to flood hydraulics and/or sedimentation. Flood hydrology models should inform the design process and result in a plan that features sufficient topographic relief to direct flood flows and diminish their detrimental effects. This will result in a range of habitat types that are sustainable over an extended period of time. The created topography should achieve the habitat goals identified above (Goals 2 and 4) while directing flood flows towards the river mouth. The design should be natural in appearance and achieved with the minimum of topographic relief. It must balance the serious need for flood accommodation in the altered and degraded watershed while achieving project habitat objectives and maintaining the historic aesthetics of the natural coastal plain**.**

The hydraulics and sediment transport of the Tijuana River have been modeled and the effective flow of the river under flood conditions have been defined. The constraints imposed by the river are presented in Section 6.0 Tijuana River Flood Hydrology Erosion and Sedimentation, and included in greater detail in Appendix B).

Goal 7. Incorporate research and adaptive management.

There is a long history of incorporating research on coastal wetlands into restoration projects at Tijuana Estuary. Such research has furthered the science of wetland restoration in general and has contributed significantly to the success of restoration projects at the estuary. Adaptive management has been applied to previous projects, such as the 20-acre Model Marsh, with lessons learned applied to this feasibility and restoration project. It was agreed that the project team would work with the research coordinator at the estuary to incorporate research and adaptive management to future wetland restoration modules.

3.2 Projects that may affect Tijuana Estuary - Friendship Marsh

Several projects have been proposed that could potentially affect this restoration project. These include the proposed restoration of riparian habitat by the San Diego County Water Authority on the Disney property, the proposed removal of the Brown fill on Hollister Street, and proposed actions associated with flood control in the river valley. These are presented in detail below.

<u>San Diego County Water Authority</u>. The San Diego County Water Authority (SDCWA) proposes to create/restore approximately 32 acres of riparian scrub habitat on a parcel of land owned by the County that was formerly farmed by Am-Sod and Disney. This project is in the conceptual stages but is on roughly the same timeline as this feasibility study (completion in Summer 2006).

The SDCWA consultants, EDAW and West Consultants, are considering lowering the elevation of the former agricultural fields to reach available groundwater. In addition, they are considering removal of a long-standing east-west berm that was constructed to protect the fields from flooding.

Creation/restoration of riparian habitat in this area may help to deflect potential floodwater from the proposed project area. However, removal of the berm may allow flood waters and sediment to encroach on the area proposed for restoration under the Tijuana Estuary - Friendship Marsh Restoration plan. Any grading of the flood plain may affect the hydraulics of the river and affect downstream flows at the Tijuana Estuary - Friendship Marsh site.

Brown Fill. The U.S. Army Corps of Engineers (ACOE) is considering funding a project to remove the Brown fill at Hollister Street. This fill, which protrudes into the main channel of the Tijuana River, deflected flood flows in 1993 to the north creating a new channel of the Tijuana River. This new channel was bridged and subsequently blocked by an "erodible berm". This erodible berm prevents water from entering the new northern channel under low flow conditions, but, theoretically, erodes under high flows allowing passage of water to the north. As the Tijuana Estuary - Friendship Marsh site is located in the southern portion of the estuary, removal of the erodible berm would help to ensure that at least part of all high flows and associated sediment are directed away from the proposed restoration area.

Flood Control Projects. The ACOE is also considering funding a study of constructing sediment control basins in Smuggler's Gulch and removing additional berms in the project vicinity. Removal of existing north/south berms in the area of Smuggler's Gulch could result in flood waters having a greater impact downstream in the area of Tijuana Estuary - Friendship Marsh.

4.0 RESTORATION ALTERNATIVES

Project restoration alternatives were developed that attempt to balance the preservation of existing valuable habitat with restoration of degraded habitat. Based on extensive habitat surveys and analysis of the rapidly changing environment in the project area, three project alternatives were designed to meet the goals presented in Section 3.0 Restoration Goals (Figures 4-1 through 4-3).

4.1 Berm Configuration and Impacts

All three restoration alternatives were designed with topographic relief in the form of a protective berm to protect the restoration from Tijuana River flood flows. This berm would be connected to an existing berm originally built to protect agricultural lands from flooding. The existing berm, also known as the AmSod berm after a sod-growing company that once farmed the protected parcels, has been an issue in flood control studies of the Tijuana River Valley. The most recent comprehensive study, completed in 1994 (BSI 1994), recommended removal of this and other unpermitted berms in the river valley. The berm is also an issue with the proposed San Diego Water Authority riparian restoration project in the area with the USFWS recommending its removal as part of that project. Despite these recommendations, the AmSod berm remains in place with no specific plan for its removal. Due to the uncertainty of the berm's removal, this feasibility and design study has been designed with the berm in place and extended as indicated in Figures 4-1 through 4-3.

The extension of the existing berm is designed as a barrier to low flood flows and a filter for larger flows. The intent is to keep sediments from impacting the marshland restoration, while ensuring that floods of differing magnitudes do not damage property within the river floodplain. The berm will impact approximately 8.86 acres of habitat. This figure includes 2.17 acres of southern coastal saltmarsh, 2.99 acres of disturbed southern coastal salt marsh, 2.09 acres of disturbed mule-fat scrub, 0.03 acre of disturbed southwest willow scrub, 0.04 acre of non-native grassland, 0.11 acre of disturbed upland, 0.06 acre disturbed habitat, and 1.37 acres of transitional habitat. These impacts will be mitigated by vegetating the created berm with high salt marsh and transitional plant species and through the creation of high quality coastal salt marsh habitats within the restoration project.

4.2 Design Alternatives

Three design alternatives are presented below. Each design reflects variations in size, impacts to existing resources, channel and tidal basin configurations, and habitat distributions.

4.2.1 Alternative A

Alternative A was designed to meet the habitat goals presented in Section 3.0 while incurring the least amount of impact to existing high salt marsh and salt panne habitats. However, the design was based on vegetation surveys conducted in 2004, prior to the catastrophic sediment deposition that occurred in January 2005. The decision process for selecting a Preferred Alternative had been completed before the January 2005 deposition event rendered some of the design features obsolete. For example, Alternative A was designed to preserve existing high salt marsh and salt panne habitat that supported a high density of Belding's savannah sparrows (*Passerculus sandwichensis beldingi*) detected during 2004 focused surveys (refer to Section 7.0 Biological Resources for details). Thus, wetland restoration opportunities were restricted in the center portion of this restoration alternative as shown in Figure 4-1. However, following the 2005 deposition event, the roughly circular area located west of Monument Road and the Goat Canyon Sedimentation Basins was covered with up to 2 feet of sediment. As a result, this area no longer supports high salt marsh and salt panne habitat but is now dominated by exotic species and mule-fat (*Baccharis salicifolia*). Excluding this center area would no longer protect existing valuable biological resources. Instead, it would facilitate the introduction of exotic species into remaining sensitive habitats. In addition, in the southern end of the project, an area of southern coastal brackish marsh has now become highly disturbed from sediment and weed species borne by flows from both Goat and Yogurt Canyons. The proposed preservation of this area under this alternative also no longer protects valuable coastal habitat.

Alternative A was designed with three tidal basins: one large basin located south of Old River Slough, and two smaller basins located north of Old River Slough (Figure 4-1). The larger basin would support subtidal, mudflat, low salt marsh, mid-high salt marsh and transitional habitats. The tidal and mudflat habitats were configured to provide islands that could serve as bird nesting areas. The larger of the two smaller basins was designed to support mudflat, subtidal, low marsh, and mid-high marsh habitats. The smallest of the three basins was designed to support sub-tidal and mudflat habitats. These basins were designed so that all hydraulic connections were routed either directly to Old River Slough or indirectly to the slough via the recently created Model Marsh. It was anticipated that tidal flows from each basin would scour Old River Slough thereby deepening and widening this hydraulically inefficient channel. This predicted scouring action was first observed in the South Beach Slough after construction of the Model Marsh. Using these newly constructed restoration components to scour the Old River Slough would eliminate the need to dredge existing channels in order to achieve increased tidal prism. With phased construction, the scouring would also increase incrementally until the Preferred Alternative construction was fully completed and the target tidal prism achieved.

Alternative A would create approximately 202 total acres composed of 41.06 acres of subtidal habitat, 41.25 acres of mudflat habitat, 61.02 acres of low marsh habitat 49.69 acres of mid-high marsh habitat and 9.19 acres transition zone, as presented in Figure 4-1.

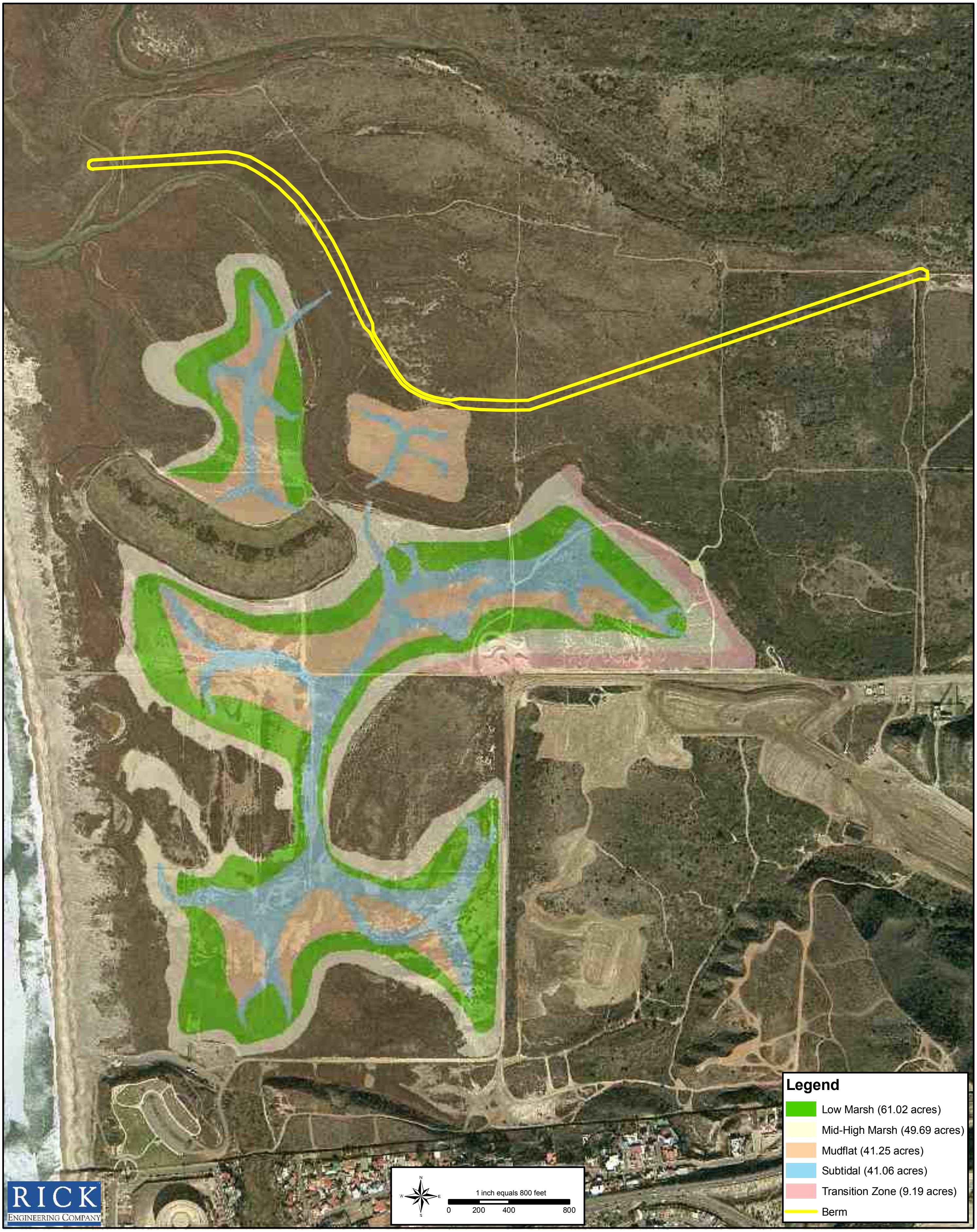


FIGURE 4-1 **Alternative A Restoration Plan and Habitat Configurations**

4.2.2 Alternative B

Alternative B was designed to meet the habitat goals presented in Section 3.0 Restoration Goals, while providing the maximum area possible for conversion to high quality salt marsh, mudflat and subtidal habitats. This alternative does not rely on the preservation of existing habitat fragments within the project area. Instead, it was designed to create a total of approximately 250 acres of restored habitat composed of 61 acres of subtidal habitat, 61 acres of mudflat habitat, 60 acres of low marsh habitat, 61 acres of mid-high marsh habitat, and 7 acres of transition zone habitat (Table 4-1).

Like Alternative A, Alternative B was designed with three tidal basins: one large basin located south of Old River Slough and two smaller basins located north of Old River Slough (Figure 4-2). The large basin would support the full range of target habitats discussed above and would provide numerous islands that may serve as bird refuges/nesting areas. The larger of the two smaller basins was designed to support mudflat, subtidal, low marsh, and mid-high marsh habitats. The smallest of the three basins was designed to support subtidal and mudflat habitats. Like Alternative A, Alternative B provides for direct hydraulic connections between each basin and Old River Slough or indirect connections to the slough via the Model Marsh. As presented previously, these connections are expected to produce a natural scouring of these tidal channels.

4.2.3 Alternative C

Alternative C is similar to Alternative A and was designed to meet the habitat goals presented in Section 3.0 Restoration Goals (Figure 4-3). However, Alternative C is designed to impact an intermediate amount of degraded high salt marsh and salt panne habitat. Under this alternative, a portion of the high salt marsh habitat that previously supported Belding's savannah sparrow before January 2005 would be preserved as an island and the area of brackish marsh to the south would be retained (Figure 4-3). However, as presented in Alternative A, the design of this alternative was based on data collected in 2004, prior to the catastrophic sediment deposition event of January 2005. Currently, these areas no longer support high quality wetland habitats. Instead, preservation of these selected areas would only facilitate the introduction of exotic species into remaining sensitive habitats.

This alternative would create a total of approximately 217 acres of restored habitat composed of approximately 43 acres of subtidal habitat, 54 acres of mudflat habitat, 60 acres of low marsh, 51 acres of mid-high marsh, and 10 acres of transition zone, as presented in Table 4-1.

Table 4-1. Habitat Types and Acreage Created by Each Restoration Alternative

Alternative	Habitats Created (acres)					
	Subtidal	Mudflat	Low Marsh	Mid-High Marsh	Transition Zone	Total Restoration Area
Alternative A	41.06	41.25	61.02	49.69	9.19	**202.21**
Alternative B	61.15	60.66	60.03	61.32	7.11	**250.27**
Alternative C	42.94	53.66	60.19	50.83	9.62	**217.24**

FIGURE 4-2 **Alternative B (Preferred) Restoration Plan and Habitat Configurations**

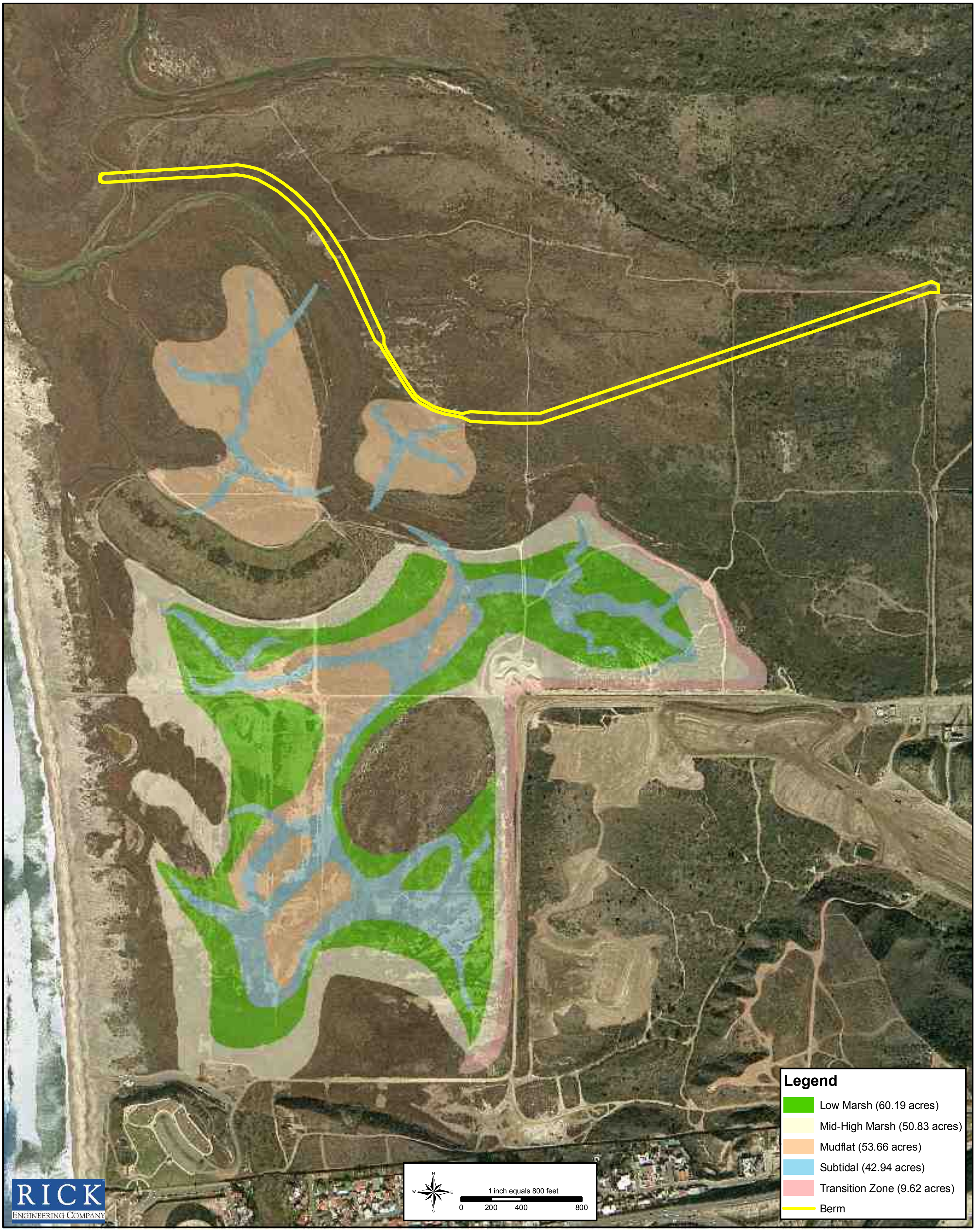


FIGURE 4-3 **Alternative C Restoration Plan and Habitat Configurations**

The majority of habitat created in Alternative C is located south of Old River Slough and was designed with two lesser basins located north of Old River Slough. The larger basin was designed to support subtidal, mudflat, low marsh, mid-marsh, and transition zone habitats, while the smaller basins are dominated by mudflat. The larger basin includes several islands for avian refuges/nesting areas.

Like the other alternatives, the three basins that make up Alternative C were designed so that all hydraulic connections were routed either directly to Old River Slough, or indirectly to the slough via the Model Marsh (Figure 4-3). Again, it was anticipated that tidal flows from each basin would scour Old River Slough thereby deepening and widening this hydraulically inefficient channel.

4.3 Selection of the Preferred Alternative

The project RFP stipulated that the three project alternatives be presented to the combined Technical Advisory Committee and Research and Restoration Committee for selection of a Preferred Alternative. Accordingly, a meeting of the combined committees was held August 18, 2004. Upon presentation of the three alternatives and thorough discussion, it was decided that the feasibility and design study should adopt Alternative B as the Preferred Alternative. Alternative B was selected in order to restore the largest area possible while also achieving the restoration goals outlined in Section 3.0. This alternative was also best suited to the post January 2005 habitat configurations existing within the project area. Thus, Alternative B**,** hereafter referred to as the Preferred Restoration Project Alternative (Figure 4-2), was further refined in terms of design and subjected to various environmental analyses. The results of these analyses are presented in the following sections of this report.

4.4 Sensitive Habitats

The vegetation communities of the project area were mapped during the spring of 2004 (Figure 4-4). Details on surveys conducted for biological resources are presented in Section 7.0 Biological Resources and are summarized here. The proposed project would result in impacts to habitats that are considered sensitive by the resource agencies. However, these habitats have been severely impacted by sedimentation, particularly from Goat Canyon. As a result, areas that were once considered highly valuable for wildlife, such as salt marsh/salt panne habitat, are now buried under up to 2 feet of sediment or have been converted to weedy upland habitats.

The completion of the Goat Canyon Enhancement Project, which includes a series of sedimentation basins to capture sediment from Mexico, was to have removed the major source of the disturbance. However, recent sediment deposition has converted these areas to disturbed uplands. In general, the elevations of much of the project area have been raised over the past 10 – 20 years and are now above the influence of tidal action, even during extreme events. In addition, much of the sediment that has impacted the system remains in the project area and will likely be mobilized by future rain events. Each of the project alternatives was designed to minimize the detrimental impacts associate with mobilized sediment.

FIGURE 4-4 **Vegetation Communities/Habitats within the Project Area, 2004**

Implementation of the proposed project would impact primarily disturbed habitats including disturbed salt marsh, disturbed salt marsh/salt panne habitat, disturbed mulefat scrub and disturbed upland habitats. These degraded habitats would be converted to high quality wetland habitats.

5.0 ANALYSIS OF COASTAL PROCESSES EFFECTS ASSOCIATED WITH THE TIJUANA ESTUARY RESTORATION PROJECT

This chapter presents a summary of the analysis conducted by Dr. Scott Jenkins and Joseph Wasyl of Dr. Scott A. Jenkins Consulting. This summary was prepared by Tierra Environmental Services (Tierra) and any errors or omissions in the summary are the responsibility of Tierra. The full report prepared by Jenkins and Wasyl is presented in Appendix A.

5.1 Introduction

This two-part study addresses the potential impacts that the Tijuana Estuary Friendship Marsh Restoration project may have on the coastal processes of the neighboring littoral region. Part I of this study evaluates ongoing beach retreat in the lower Silver Strand Littoral (coastal) Cell and its effects on the life span of the existing estuary under a "no project alternative". It also evaluates how wetland restoration at Tijuana Estuary may reduce these retreat rates. Part II evaluates the tidal hydraulics of the preferred restoration alternative. The analysis calculates tidal ranges, elevations, velocities, residence times and sediment fluxes in the newly created tidal basins, marsh plains, and channel systems. This analysis, along with an evaluation of habitats created by the project, will help to determine maintenance requirements for the restoration.

5.1.1 Overview

Wave climate and littoral transport suggest that existing beach retreat rates will result in long-term erosion and eventual breaching of the barrier sand spit that protects the ocean frontage of the estuary system. The time horizon for this outcome under the No-Project Alternative is about 2045. This will not result in complete and immediate destruction of the Tijuana Estuary, but it will add another mechanism of gradual degradation through accelerated channel sedimentation and reduction of tidal inundation. These effects will be most pronounced during periods of dry climate. This slow degradation can be significantly reduced by a restoration project that substantially increases the tidal prism.

The preferred restoration plan meets restoration goals by achieving tidal inundation during high tides of about 250 acres of new wetland habitat. This figure includes approximately 61 acres of subtidal habitat, 61 acres of mud flats, 60 acres of low marsh, 61 acres of mid and high marsh habitat and 7 acres of transitional habitat. The tidal prism of the newly created wetlands under the preferred restoration alternative will be about 420-acre feet (ft) volume, increasing the tidal prism of Tijuana Estuary system to a total of approximately 750-acre ft. This would more than double the existing tidal prism, restoring it to about half of it's estimated historic maximum of 1,550 acre-ft. (assessed by inference of a U.S. Coastal Geological Survey [USCGS] map of the estuary produced in 1852). This increase of tidal prism will reduce in-filling of the tidal inlet and main channels of the river and estuary associated with influxes of beach sediment. This change in tidal dynamics will allow these sediments to remain in the beach system. With a combined 750 acre-feet of tidal prism, the restoration project will reduce littoral sediment influx rates by 57% and bring the estuary system close to equilibrium with the long term erosion and deposition patterns of the Silver Strand.

Unfortunately, this increase in tidal prism may be insufficient to flush coarse and fine grained sediments entering the newly created wetlands from adjacent Goat Canyon and Yogurt Canyon. Deposition rates of sands and silts from Goat Canyon alone have been estimated to be as high as 55,000 cubic yards per year based on events in January 2005, and present a persistent, annual maintenance requirement. However, it should be noted that a series of sediment detention basins were constructed at the mouth of Goat Canyon in 2004-2005 to address this problem. With regular maintenance of these basins, sediment influx from this canyon should be reduced or eliminated. Nonetheless, a substantial amount of sediment from former depositional events already exists in the project area. This sediment will need to be managed as part of the restoration plan. In addition, the management plan must address sedimentation from potential catastrophic events, such as failure of the Goat Canyon sedimentation basins.

To avoid the environmentally damaging effects of continued dredging within the restoration area, a fixed-place sediment bypass system comprised of buried fluidizer pipes is proposed for the sub-tidal channels and basins of the restoration. Weekly operation of this system during wet weather months should flush new sediment deposition from the restoration to the main river channel at a rate that can match the maximum influx rate of sediment from adjacent canyons. Periodic operation of the mobile fluidizer system will also increase sediment yield to the beach, to further offset long-term loss of beach width. The fluidizer system is presented in detail in part II of this analysis.

5.2 Beach Retreat Impacts on the Tijuana Estuary – Existing Conditions

This segment of this report addresses beach profile and shoreline evolution of the Silver Strand beaches and estimates the impacts of beach retreat on the barrier sand spit fronting the western edge of the Tijuana Estuary system. The data necessary to make these calculations are: 1) an unbroken wave record for longshore and cross-shore littoral transport reshaping the beach; 2) a set of beach profile measurements used to assess beach stability, and 3) USGS river level gauge station measurements assessing additional flow and sediment yield. These data sets were incorporated as time-step inputs in a beach evolution model (Jenkins and Inman, in press). Data sets were divided into three major time periods based on historic climate/sediment patterns: the 1900-1938 El Niño-dominated warm-wet period prior to construction of dams on the Tijuana River and major San Diego Harbor dredging projects; the cool-dry La Niña-dominated period of 1944-1977; and the El Niño-dominated warm-wet period of 1978-1995. Data sets were also used to provide a reasonable estimate of future climate effects on beach retreat rates. By comparing the modeled beach impacts of the preferred restoration alternative versus the known beach responses to the existing river system after 1983, the requirement for a protective berm system was established in the restoration plan (see section 6.0 Tijuana River Flood Hydrology, Erosion and Sedimentation, for details).

5.2.1 The Ancient Tijuana River Shoreline

To understand the Silver Strand shoreline it is important to review its geologic history and its littoral setting. Both Tijuana Estuary and the Silver Strand beaches have been formed by processes of erosion and the action of interglacial cycles which have resulted in dramatic variations in sea level over the last 350,000 years. At times, sea level fell to about 135 meters

(443 ft.) below its present level putting the ancient shoreline approximately 4.6 km (2.9 miles) further out on the continental shelf than its present location. The Tijuana River Valley was cut during such a period of very low sea level. When sea level again rose, the deep river valley became a bay that eventually filled with sediments. Sediment deposited at the mouth of the river was then distributed by waves and littoral drift along the shoreline.

Today the ancient bay is almost completely filled, leaving only a shallow estuary (Tijuana Estuary). Currently, river channels carry most of the sediment yield of the Tijuana River to the open coast, where littoral drift spreads these sediments across the mouth of the estuary to form beaches and a barrier sand spit. In addition to sediments carried by the river from upland sources, beaches are also supplied by coastal bluff erosion and sediment drift from adjacent shorelines.

5.2.2 Components of the Silver Strand Sediment Budget

Coastal processes controlling beach structure and the movement of sediments can be represented in a *sediment budget* with the budget area called a *computational cell.* All local sediment transport processes occur within a geomorphic unit known as a *littoral cell* (Inman 1960). A littoral cell essentially describes all of the sources, sinks, and pathways of sediment in a given region. The Silver Strand beaches and Tijuana Estuary belong to the Silver Strand Littoral Cell shown in Figure 5-1. This figure shows the location of the Silver Strand cell in relation to other cells of the California Bight.

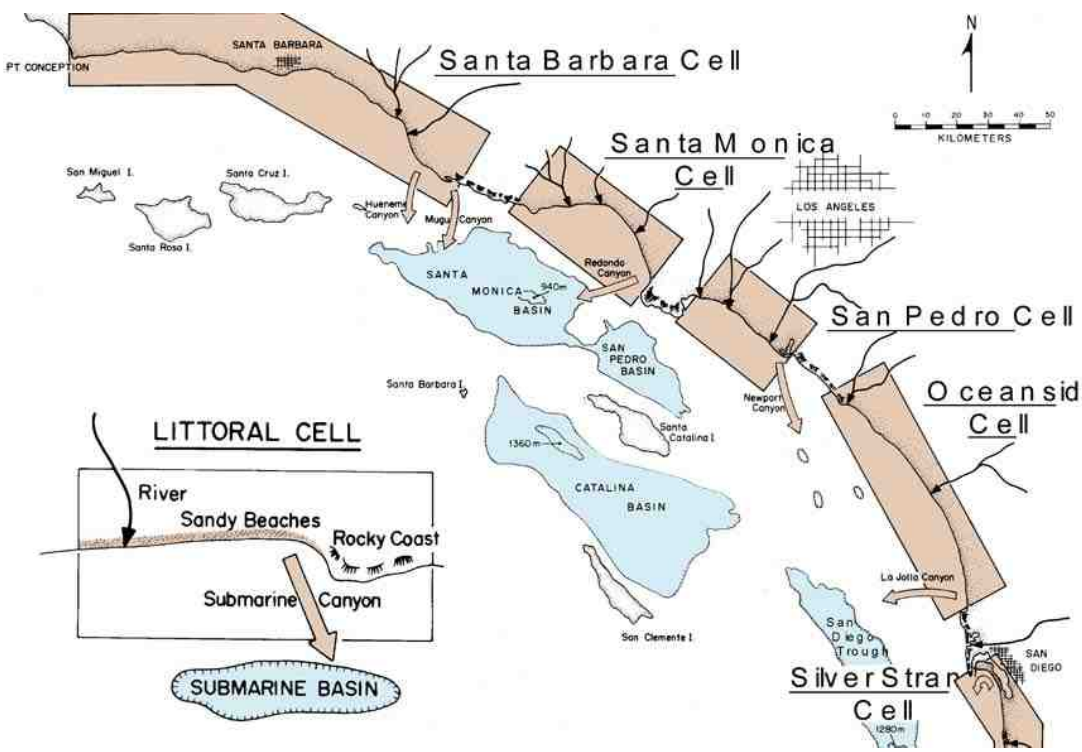


Figure 5-1. Littoral Cells of the California Bight in Relation to the Silver Strand Cell

Sand on the beaches continually migrates along the shoreline in the direction of the long term average littoral drift until it meets an obstruction or is trapped. Littoral drift in the Silver Strand Cell is unique among the 5 major cells of the Southern California Bight in two ways. First, these sediments are not ultimately deposited in an active submarine canyon. Second, the primary direction of littoral drift (and sediment transport) in the Silver Strand is from south to north (see Figure 5-2). This drift explains the formation of the Zuniga Shoal, the long term increase in beach widths at Coronado Island, and the resulting long-term potential for beach width loss at Tijuana Estuary.

The sediment budget area for the Silver Strand Cell extends from the headwaters of the Tijuana River, to the mouth of the river, north to the beaches and shoals off Coronado Island, and south to the Rosarito area beaches in Baja California, Mexico. The budget area also includes the offshore beach profile out to the depth where wave driven sediment transport vanishes. This oceanward (wet) boundary extends out onto the continental shelf.

The most active wet boundary portion is the surf zone and inner shore-rise profile where waves actively redistribute sediment after flood events.

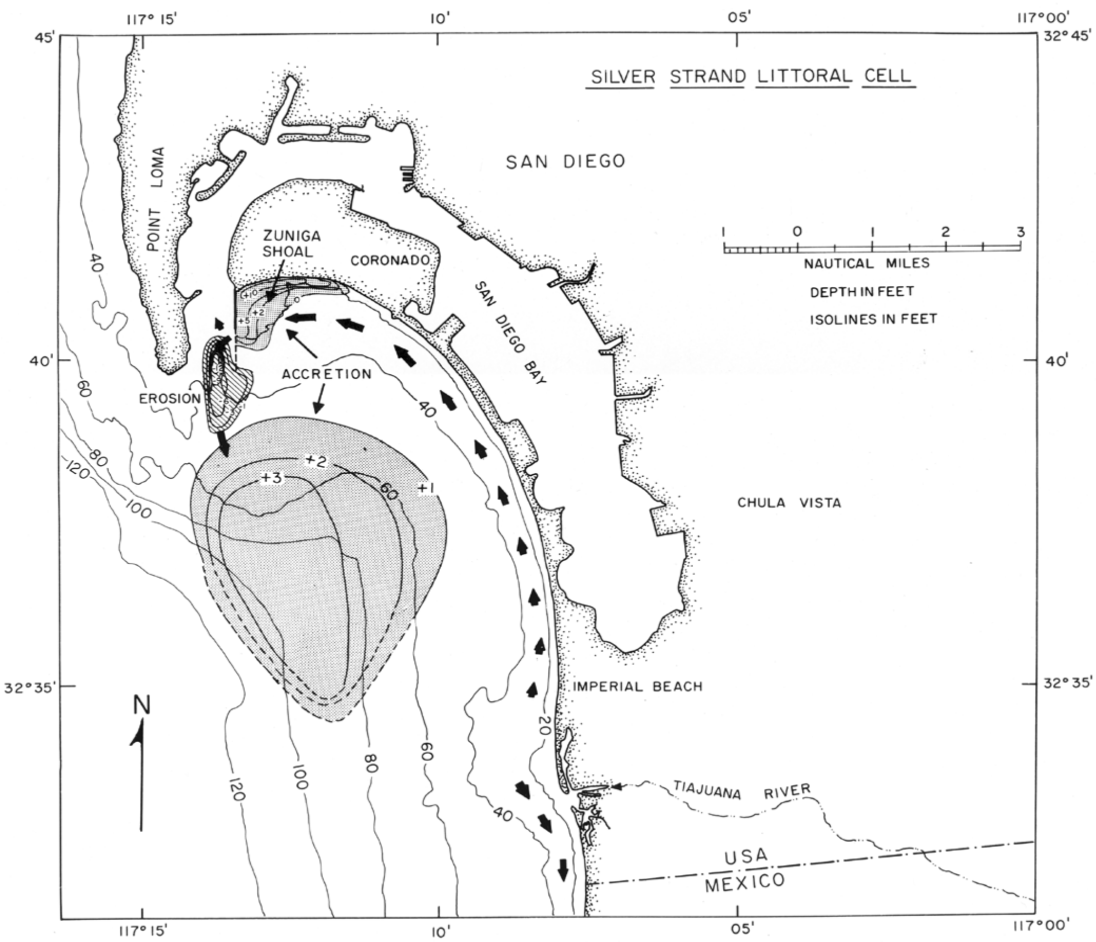


Figure 5-2. Dominant Sediment Drift and Deposition within the Silver Strand Cell

In order for the Silver Strand beaches to remain stable, the sediment supply to the computational cell must balance the sediment loss from the cell. The Silver Strand barrier sand spit and beaches were historically in a cycling equilibrium balance between sediment losses by wave erosion, and sediment supply through both river yield and littoral drift. Unfortunately, man-made structures and alterations to the natural landscape surrounding the Silver Strand have disrupted this balance.

5.2.3 Sediment Budget Analysis

The following analysis combines elements of the sediment budget with an equilibrium beach profile model in order to evaluate the impacts of the preferred restoration plan on the stability of Silver Strand beaches. Due to the lack of historical data for the immediate Tijuana Estuary region, the historic sediment budget for the Silver Strand Littoral Cell is reconstructed using surrogate data from similar littoral environments within the California bight.

Sediment budget computations using the 1900-1938 surrogate data sets revealed that the Silver Strand Littoral Cell maintained a steady state mass balance during this wet period, including a stable shoreline with negligible long-term beach erosion. This balance was maintained in the past by the unrestricted supply of new sediment from periodic Tijuana River floods. Historical photographs of the Silver Strand beaches in 1916 confirm that the dry beach backshore was much wider than today; typically 500-800 feet wide (Inman and Jenkins 1983).

Human intervention has since interrupted the equilibrium mass balance of the Silver Strand Littoral Cell, beginning with the construction of the first dams, flood control debris basins, and seawalls, all of which restrict sediment movement. The resulting total cumulative sand yield deficit to the Silver Strand Cell beaches as a consequence of dams alone has been estimated to be 6.0 million cubic yards (see Inman and Masters 1991b). This insufficient supply of sediment is currently causing the southern cell beach foreshore to recede landward. Wave action acts to further erode the sand spit and dunes protecting Tijuana Estuary, producing occasional breaching and storm over-topping. This wave erosion can release hundreds of thousands of cubic meters of beach sediments, which are then subject to littoral drift toward Coronado Island (Figure 5-2).

5.2.4 Climatic Variability Affecting Waves and Sediment Yield

Variations in Earth's exposure to the sun affect global climate and can produce periodic variations in the Earth's seasonal weather cycles. These global weather modifications are commonly known as El Niño (wet) and La Niña (dry) climate fluctuations. These climate fluctuations are further embedded in a multi-decade pattern called the Pacific Decadal Oscillation (PDO).

The long-term variability of the Pacific Decadal Oscillation (PDO) is shown in Figure 5-3. This figure reveals a number of large positive (dry weather) oscillations in the Southern Oscillation Index (SOI) between 1944 and 1978 corresponding to La Niña dominated climate; and a series of very large negative (wet weather) oscillations occurring between 1978 and 1995 which correspond with El Niño dominated climate.

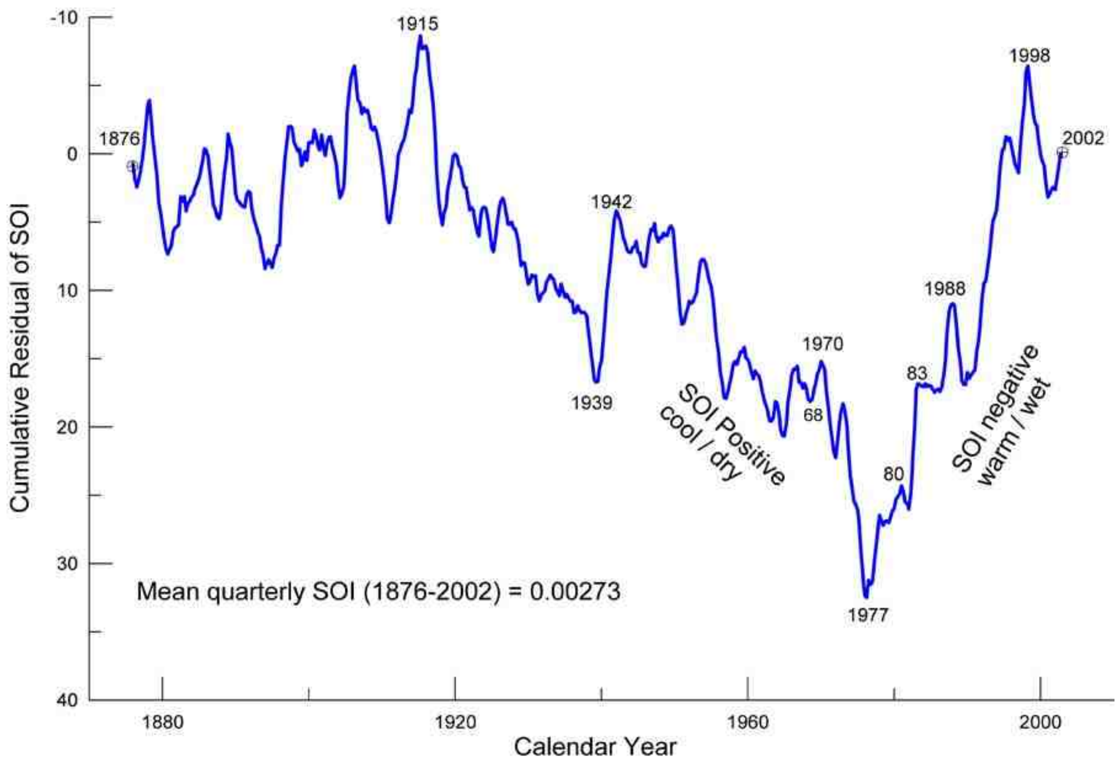


Figure 5-3. Cumulative residual of Southern Oscillation Index (SOI) showing cool/dry La Niña and warm/wet El Niño cycles

As stated previously, between 1944 and 1978, La Niña-dominated pressure systems prevailed. Winters were moderate with low rainfall, and storm tracks bearing strong winds rarely reached southern California. Summers were dry with the largest summer swells coming from very distant Southern Hemisphere storms. This climate period resulted in very little wave erosion of coastal beaches, low sediment delivery by the Tijuana River, and low sediment transport by littoral drift from the Tijuana Estuary region to northern sections of the Silver Strand Littoral Cell.

Beginning with the El Niño years of 1978-1979 and extending until the present, the wave climate in southern California changed dramatically (Figure 5-4). Previously gentle, northwesterly winter waves were replaced by high energy waves approaching from the west or southwest. Calm summer waves were also replaced by shorter period tropical storm waves from more immediate waters off of Central America. This period also produced a dramatic increase in both the number and intensity of extreme wave events affecting the entire Silver Strand Cell. The net result of these changes was an accentuated northward component (away from Tijuana Estuary) of the long-shore sand transport as well as increased wave erosion in the Silver Strand Littoral Cell.

Data analysis shows that waves were on average smaller, and approached the Silver Strand from a more northerly direction during the cool-dry La Niña dominated period between 1945 and 1977. During the warm-wet El Niño phase beginning in 1978, waves approaching the Silver Strand from deep water increased in height, and shifted to a more southerly direction (Figure 5-4). This wave pattern change accelerated the beach erosion near Tijuana Estuary and increased the northward transport of sand within the southern littoral cell segment.

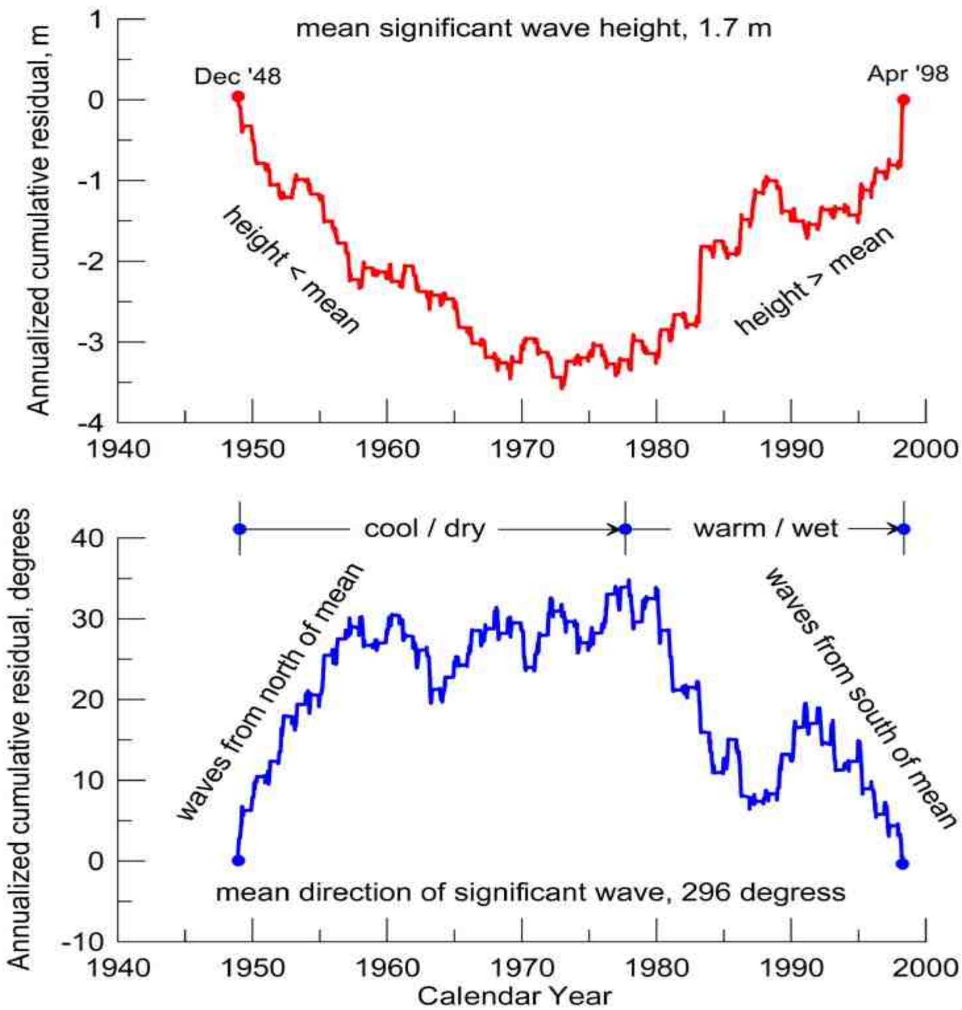


Figure 5-4. 50 year record of wave height and direction for North Pacific winter (Dec-Apr) waves

Irregularities in the broad continental shelf off of the Silver Strand also pose unique erosion risks to the Tijuana Estuary region. These irregularities refract incoming waves into complex directional patterns resulting in segments of higher and lower wave energy. Long-term wave records reveal a consistent pattern of larger, high energy waves focused on the Tijuana Estuary region. This means that this segment of the Silver Strand is subject to greater wave erosion under all climate patterns than other adjacent segments.

La Niña (cool-dry) and El Niño (warm-wet) periods also affect the sediment yield of the Tijuana River and other streams of the Silver Strand Littoral Cell. Beginning in 1978, a succession of powerful El Niños, particularly those in 1978, 1980, 1983, 1993 and 1995, resulted in high rainfall and subsequent high sediment loads carried in flood waters of the Tijuana River (Inman & Jenkins, 1997). A similar succession of El Niño floods resulting in high sediment yields occurred in 1927, 1937, 1938, 1941 and 1943. These historic periods of high sediment yield from the Tijuana River are very important to the nourishment and long-term stability of the Silver Strand beaches. They provide a significant reserve of sand to help these beaches survive wave erosion during protracted drought periods when no new sand is delivered. Historically, beach sediment supplies were also aided by bluff and dune failures. Unfortunately, hardening of these formations with coastal structures has eliminated this auxiliary source, making the river sediment yield during warm/wet periods even more critical to beach stability.

Because of upstream dam building, the sediment yield of recent floods during post 1943 El Niño-dominated climate is only a fraction of what it once was during previous warm/wet periods. Consequently, it is critical that sediment yield by the Tijuana River not be restricted further by the proposed restoration project.

5.2.5 Long-Term Averages for Sediment Delivery

As stated previously, the history of the far-field sediment budget can be divided into three long-term averages: the 1900-1942 warm-wet period prior to construction of dams on the Tijuana River and major San Diego Bay dredge projects; the cool-dry La Niña dominated period of 1944-1977; and the El Niño dominated warm-wet period of 1978-1995. In this discussion, the Silver Strand Littoral Cell sediment balance is further divided geographically into northern, central and southern cell segments. The southern cell segment contains Tijuana Estuary.

During the 1978-95 warm/wet climate period, long-shore sediment transport volumes in the Southern Control Cell were typically 35,000 m^3/yr. This volume is about 10,000 m^3/yr more than the preceding cool/dry period and roughly unchanged from natural conditions between 1900-1942. The 1978-1995 period differed from previous warm/wet climate periods because of a dramatic reduction in Tijuana River sediment yields due to dam construction and hardening of watershed surfaces (Chang 2004). During this normally productive period, Tijuana River sand yield to the Southern Control Cell dropped to only about 62,000 m^3/yr; a 59% reduction from natural conditions. This reduced volume was insufficient to compensate for sediment losses incurred during the previous cool/dry period.

In the post-dam modern period, the Southern Control Cell achieves a net sediment gain of only about 7,000 m^3/yr during a warm/wet climate period, but suffers a net loss of 20,000 m^3/yr during a cool/dry period. This represents a net long-term loss of 13,000 m^3/yr of sand when averaged over a complete cycle of the Pacific Decadal Oscillation. This net loss is more significant when compared to the 20,000 m^3/yr gain historically typical for the Southern Cell. As a result of this long-term deficit, the barrier dunes which protect the Tijuana Estuary no longer continue to build and the existing beaches have begun to erode and recede landward.

In contrast, northern and central segments of the Silver Strand Cell have experienced net long-term gains during the modern period, with a long term gain of 10,000 m^3/yr of sand averaged over both cool/dry and warm wet climate periods. This gain is primarily due to beach disposal of dredged material from harbor development projects like construction of Coronado Cays. The gains have been the greatest in the Northern Control Cell, primarily due to construction of the Zuniga Jetty extension and the destruction of barrier dune fields. These sediment accumulations have also resulted in the build up of the Zuniga Shoal (Figure 5-2).

5.2.6 Sediment Budget Losses Due to Recharge

During an intense flood event, river flows scour sediments from the river channel, pushing these sediments into the nearshore zone. After the flooding period ends, recharge moves littoral sediments back into the river mouth and channels. When the recharge zone can accept no new sediment, the inlet may close. During the recharge period, most of the recharge volume is recovered by the lower river channels in the first 11 months (with continual recharge at a very low rate for the next 3 years). This volume is largely made up of the same sand deposited immediately after flooding.

Within the estuary, flushing and recharge occurs during each tidal cycle. Tidal channels are connected to the main river channel and remain open and active as long as the volume energy of fluid exchange (the tidal prism) in each tide sequence is sufficient to reflush the channel after recharge. In estuarine systems, channel closure tends to occur when the tidal prism is too small to reflush all of the recharge sediments. If the recharge rate continues to exceed flushing over time, the inlet channel will close intermittently.

Long-term averages for wave energy, littoral drift and shoreline retreat in the immediate vicinity of Tijuana Estuary are graphically represented in Figure 5-5. Because of the small tidal prism of existing channels in Tijuana Estuary, tidal flushing is currently negligible. This leaves the estuary vulnerable to tidal channel closure and the resulting potentially negative habitat impacts associated with such closure.

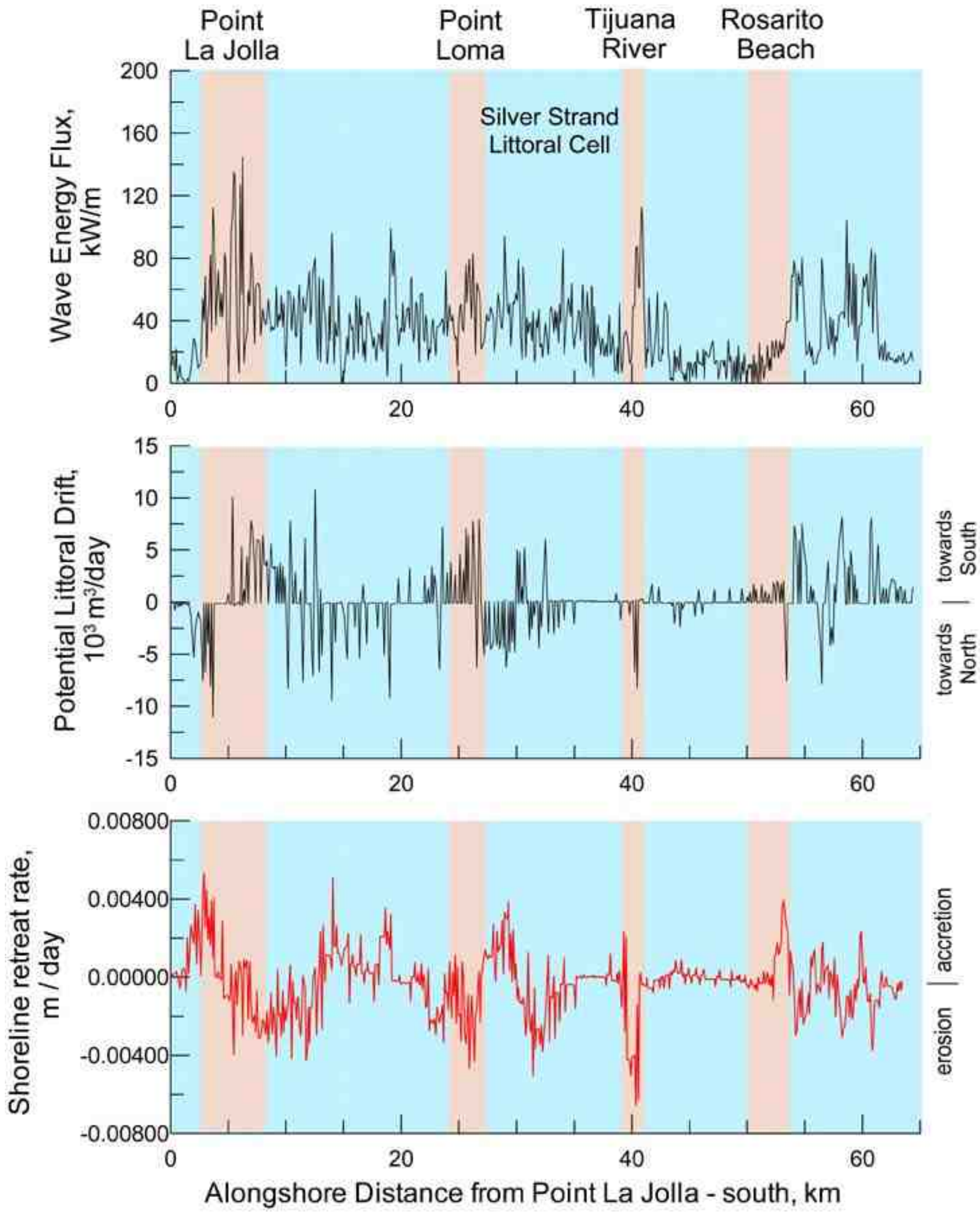


Figure 5-5. **a) Historic wave energy flux; b) historic littoral drift; c) predicted shoreline retreat rate for the no-project alternative.**

5.2.7 Results of Beach Profile Evolution Modeling

Study results indicate that the long-term beach retreat rate at the Tijuana Estuary under existing conditions is about 2.2 m/year. At this rate, without any restoration activity, the barrier spit would begin to exhibit breaches by about the year 2045 . Breaches in the barrier spit would result in migrating secondary inlets, each of which divert a fraction of the estuary tidal prism away from the primary inlet at the river mouth. This diversion will in turn reduce tidal flushing of the river mouth, thereby increasing recharge sedimentation in the inlet channel during periods without compensating riverbed scour. The long-term loss of beach width and ultimate breaching of the barrier spit will not result in complete and immediate destruction of Tijuana Estuary, but it will result in slow degradation that will be most pronounced during dry climate.

The predicted gradual loss of beach width can be significantly reduced by a wetlands restoration effort that substantially increases the tidal prism. With increased tidal prism, recharge rates are reduced and less (potentially zero) sand is scavenged from the beach due to recharge. The preferred restoration alternative has the potential to increase the tidal prism of the existing estuarine system by a factor of 2.3, thereby bringing the inlet close to a condition of self-sustaining equilibrium.

5.3 Hydraulics and Transport

In this section, the grading design for the preferred restoration alternative is examined to evaluate its tidal hydraulics and tidally induced sediment transport. This analysis is compared to the same features of the existing Tijuana Estuary. Figure 5-6 shows the physical layout of the restoration plan, its primary structural components, and the general arrangement of habitat types.

This analysis begins with a selection of 48-hour (2 day) tidal elevation data recorded between 1990-2002 at the nearby Scripps Pier NOAA tide station (Table 5-1). The data selection identified records having the largest and the smallest diurnal range, and ranges that most closely matched the long-term mean. Beach evolution models estimated tidally driven influxes of littoral sediments during a hypothetical heavy influx month following restoration construction. These results were used to assess the maintenance requirements of the restoration. Simulations of the water surface elevations, channel velocities, duration of tidal inundation, and the resulting habitat mix are calculated for a full range of potential high water levels created by the preferred restoration alternative and the existing estuarine system. These are used to determine the subtidal and intertidal areas, tidal prisms and hydroperiod functions for the restoration. Results show the full range of improvements achieved by the restoration.

To determine maintenance needs, the volume flux of littoral sediments deposited in the recharge zone of the inlet channel is estimated immediately after completion of the restoration project. A similar calculation for sand influx into the estuarine system under the No Project Alternative was performed. From these calculations and the previous history of mechanical maintenance of the existing inlet, we can estimate the required pumping rates and volumes for the proposed maintenance system.

Figure 5-6. Preferred (Alternative B) Restoration Plan and habitat configurations

5.3.1 Tide and Sea Level Variations

Although intuitively, we would expect the mean sea level shown in Table 5-1 to be 0.0 ft, this value is actually + 0.19 ft. or about 2.5 inches. This is due to the long-term rise in sea level during the last two centuries. Global warming is believed to be responsible for the bulk of this rise which has been estimated at 0.7 ft./100 yr. in this century. However, Flick and Cayan (1984) have also shown that seasonal warming and cooling accounts for an inter-annual variation in mean sea level of about 0.5 ft. Even more dramatic are the thermal expansion effects which a powerful El Niño like 1997 can have, producing more than a 0.5 ft. rise in mean sea level. When the astronomic tides oscillate around mean sea levels displaced by one or more such large sea level anomalies, the extreme high water levels can be significantly greater than would be expected from tidal constituents. When the time histories of the highest extreme water level events measured at Scripps Pier are reconstructed, sea level anomalies become as high as 0.88 to 1.31 ft above the mean sea level datum. In contrast, extreme neap tides may produce a diurnal tidal range of only 3.11 ft. However, such extreme low tides are exceedingly rare, occurring only once every 18.6 years (Wood 1986).

Table 5-1. Mean tidal elevations for lowest, mid and highest tides, NOAA Station, Scripps Pier, La Jolla, CA

Mean Higher High Water (MHHW) = +2.81 ft. NGVD
Mean High Tide (MHT) = +2.06 ft. NGVD
Mean Sea Level (MSL) = +0.19 ft. NGVD
Mean Lower Low Water (MLLW) = -2.56 ft. NGVD

5.3.2 Tidal Hydraulics and Storage in Tijuana Estuary

Storage rating curves are given in Figure 5-7 for the preferred restoration alternative and the existing estuary, respectively. Due to sediment infilling of the tidal basins after extreme floods, the current estuarine system is not influenced by the full range of ocean tides. To address this problem, the proposed restoration more than doubles the tidal prism and storage capacity of the existing estuary (Table 5-2). Once completed, the restoration will provide a maximum potential increase in tidal prism for mean tidal ranges of 550 acre-ft., or 810 acre ft. during higher spring tides. The combined preferred restoration alternative and existing estuary will produce a total potential prism of 1,490 acre ft. which is very close to the 1,600 acre ft of prism recommended to indefinitely maintain tidal inlets in this environment (Goodwin and Florsheim 1997).

Vigorous tidal flushing is expected in the restored estuarine system because the bulk of the storage volume of both the existing estuary as well as the restoration is above 0.0 ft NGVD (see Figure 5-7). Only this portion of the total volume stored within the estuary is exchanged with each tidal sequence. In addition, the tidal inlet sill depth after the restoration is estimated to be = -1.0 ft NGVD during spring tides and 0.0 NGVD for mean tides. This sill height allows for adequate exchange of storage volumes.

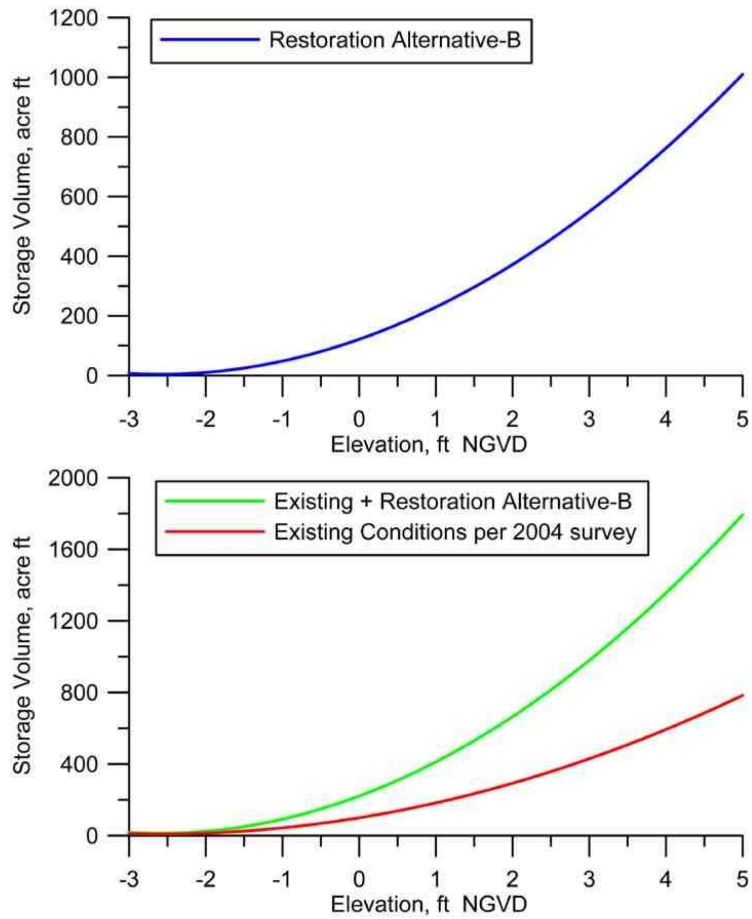


Figure 5-7. Storage volume of: a) Tijuana Estuary, b) Restoration Alternative-B,) Combined Restoration Alternative-B and existing estuary

Please note that the previous volume predictions represented in Table 5-2, do not consider tidal muting which will result in slightly lower storage volumes. Hydraulic models will determine how much of this potential prism the restoration will actually achieve once tidal muting is considered.

5.3.3 Tidal Hydraulics and Storage with Muting Effects

The inlet channel currents (solid trace) are shown in the lower panel of Figure 5-8. Tidal patterns in the estuary closely match ocean tides during the flood (incoming) tide, but lag behind on the ebb (outgoing) tide. Ebb flow initially increases in current speed with increasing water level changes in the estuary until the water surface drops close to mean sea level. Once near this level, the ebb current strength begins to decrease. This produces the lag behind ocean tides.

Table 5-2. Summary of Potential Un-Muted (Frictionless) Tidal Response for Astronomic Tides

	Existing Conditions	Restoration Plan	Combined
Potential Diurnal Mean Prism (acre ft)	420	550	970
Potential Diurnal Spring Prism (acre ft)	680	810	1490
*Mean Intertidal Area (acres)	164	212	376
Mean Subtidal Area (acres)	14.5	4	18.5
**Spring Intertidal Area (acres)	187	243	430
Spring Subtidal Area (acres)	5	0	5

* Due to MHW = +2.81 ft NGVD and MLW = -2.56 ft NGVD
** Due to EHHW = +4.26 ft NGVD and ELLW = -4.58 ft NGVD

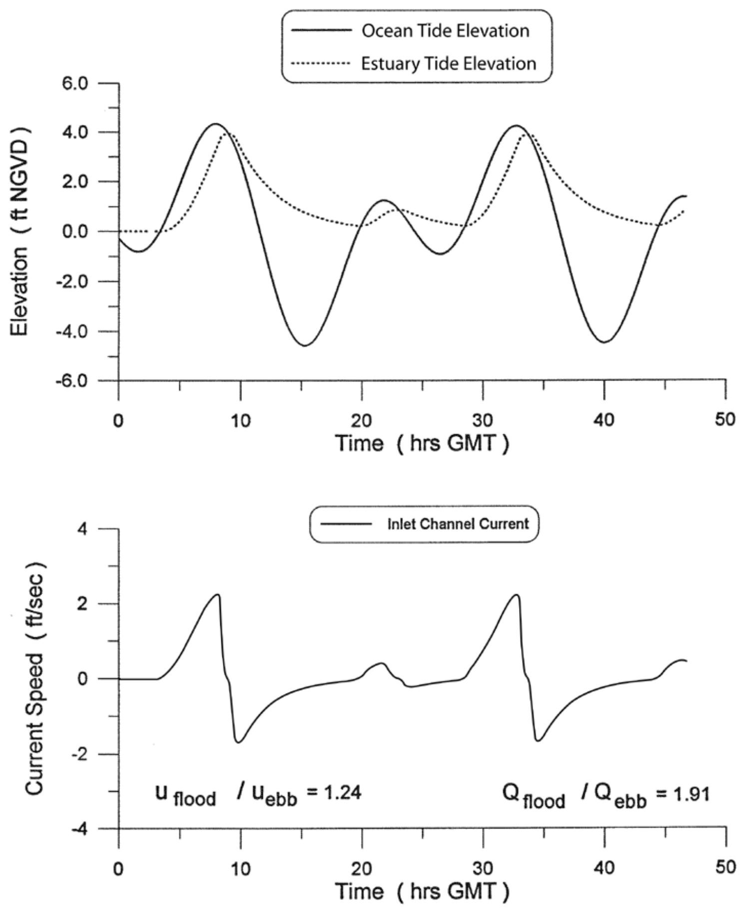


Figure 5-8. Upper figure: modeled water elevation at Phase 1 Basin Restoration Alternative-B (dotted) vs. ocean tides (solid). Lower figure: Current speed fluctuation

Tidal damping is apparent during all tides, but is more severe during the low tide phases. Most of this significant muting is due to friction effects in the shallow feeder channels and inlet sill at the mouth of the Tijuana River.

The mean range tidal response of the existing Tijuana Estuary is currently slightly less muted than the restoration area due to smaller volume exchanges that result in slower flow. As well, the mean low water level is reduced by the action of the inlet sill. This greatly diminishes the mean tidal range of the existing wetlands system, yielding only 92 intertidal acres and 47subtidal acres. This low inlet velocity combined with a low mean diurnal tidal prism of only 330-acre ft. accounts for the tendency of the existing estuarine system to fill with littoral sediments. The preferred restoration alternative should greatly limit this problem.

A summary of tidal hydraulic response, including tidal muting for the preferred restoration plan versus existing conditions at Tijuana Estuary, is illustrated in Table 5-3. This table shows that the total subtidal and intertidal habitat area produced by the restoration is 181 acres (61 + 120) for mean tidal ranges. However, additional habitat area is achieved when the astronomic tides are augmented by high sea level anomalies.

During these occasions the total subtidal and intertidal habitat area produced by the restoration may reach 260 acres.

Altogether, the preferred restoration alternative and existing estuary system will result in 750 acre ft. of mean tidal prism, expanding to 1100 acres during the highest spring tides. The restoration will also increase the size of the functioning estuary to 212 acres of intertidal habitat and 108 acres of sub-tidal habitat, to produce a combined total habitat area of 320 acres.

Table 5-3. Summary of Tidal Hydraulics Modeling Response (With Tidal Muting) to Astronomic Tides

	Existing Conditions	Restoration Plan	Combined
Diurnal Mean Tidal Prism (acre ft)	330	420	750
Diurnal Spring Tidal Prism (acre ft)	490	620	1100
Mean Intertidal Area (acres)	92	120	212
Mean Subtidal Area (acres)	47	61	108
Spring Intertidal Area (acres)	139	182	321
Spring Subtidal Area (acres)	5	61	66

5.3.4 Hydro-Period Effects on Estuarine Habitats

The other important measure of restoration performance is the hydro-period function which gives the percentage of time each elevation in the estuary is exposed above water. Tidal elevation fluctuation patterns are significant because of their effect on plant survival and growth. Even infrequent tidal inundation creates habitat for valuable halophyte (salt adapted) plant communities. Normally, the highest tides of the year (approximately + 4.5 ft NGVD) are used to define the vegetation communities associated with tidal marshes. All elevations below this level will normally have significant tidal wetland function (Josselyn and Whelchel 1999).

The upper limit of tidal marsh plant tolerance is determined by soil salinity rather than tidal inundation because these plant species are extremely tolerant of long exposure times. Soil salinity is also a product, not an average, of less frequent events that allow soil moisture to be recharged and then evaporated by long exposures. Consequently, soil salinity often increases with elevation in a tidal marsh. Ultimately, at a specific elevation, inundation is too infrequent, or rainfall is sufficient, to wash out the salts so that non-halophytic (upland) plants can effectively out-compete the halophytes.

Figure 5-9 shows that the intertidal range would be significantly increased by the hydraulic efficiencies of the preferred restoration alternative. The intertidal mudflats have expanded to lower elevations due to depression of inlet sill depths, and the upper limits of mid and high marsh have been raised due to reduced tidal muting. This increase in habitat area expands both upper and lower tidal ranges within the estuary, ultimately expanding the potential ranges of halophytic plant communities.

5.3.5 The Importance of Residence Time in Estuarine Systems

Residence time is a measure of the duration that water will be retained within an area and is an important factor in deciding how deep to excavate the new tidal basins in the restoration. Water held in basins below 0.0 ft. mean elevation experience restricted tidal flushing. The longer the residence time in deep basins, the greater the potential for stagnant water conditions to develop including decreases in dissolved oxygen, accumulation of nutrients, and adverse changes in temperature and salinity. Residence times of several days to several weeks are common within coastal lagoons subject to restricted tidal action and most organisms in these environments are tolerant of changes in water quality due to residence times up to one month. However, studies conducted at Tijuana Estuary have shown that invertebrate and fish densities begin to decline 1 to 2 months after channel closure. Water quality data taken concurrently with these events showed elevated temperatures, elevated salinity and increases in algal density.

To evaluate these concerns, residence times are calculated here for the major tidal basins of the existing estuarine system and the preferred restoration alternative. Figure 5-10 shows that the mean residence times are less than 72 hours (3 days) in the deepest basin of the preferred restoration alternative. This is well within the tolerance of resident estuarine animals and plants and will not cause adverse or lethal water quality conditions. Even during infrequent extreme neap tides during El Niño, residence times in these new basins would only increase up to 144 hours (6 days). While there may be short-term adverse conditions, these times are still within the tolerance of organisms associated with estuarine environments.

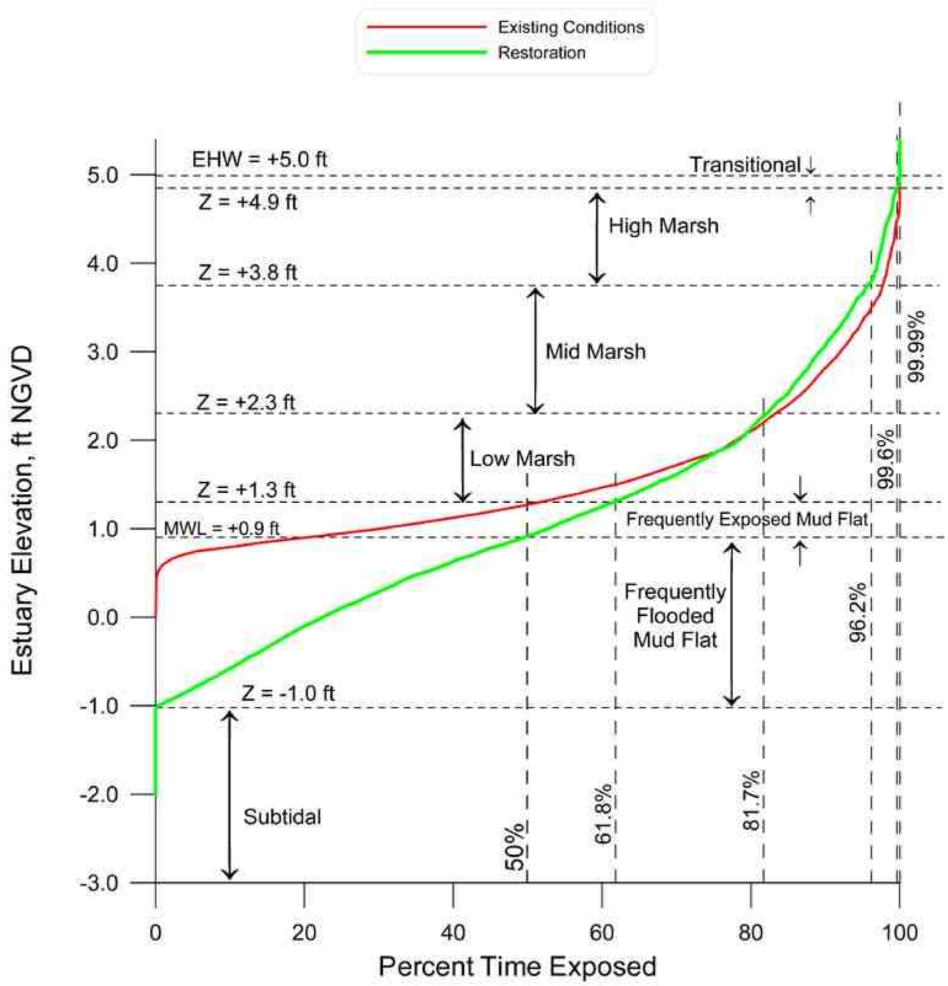
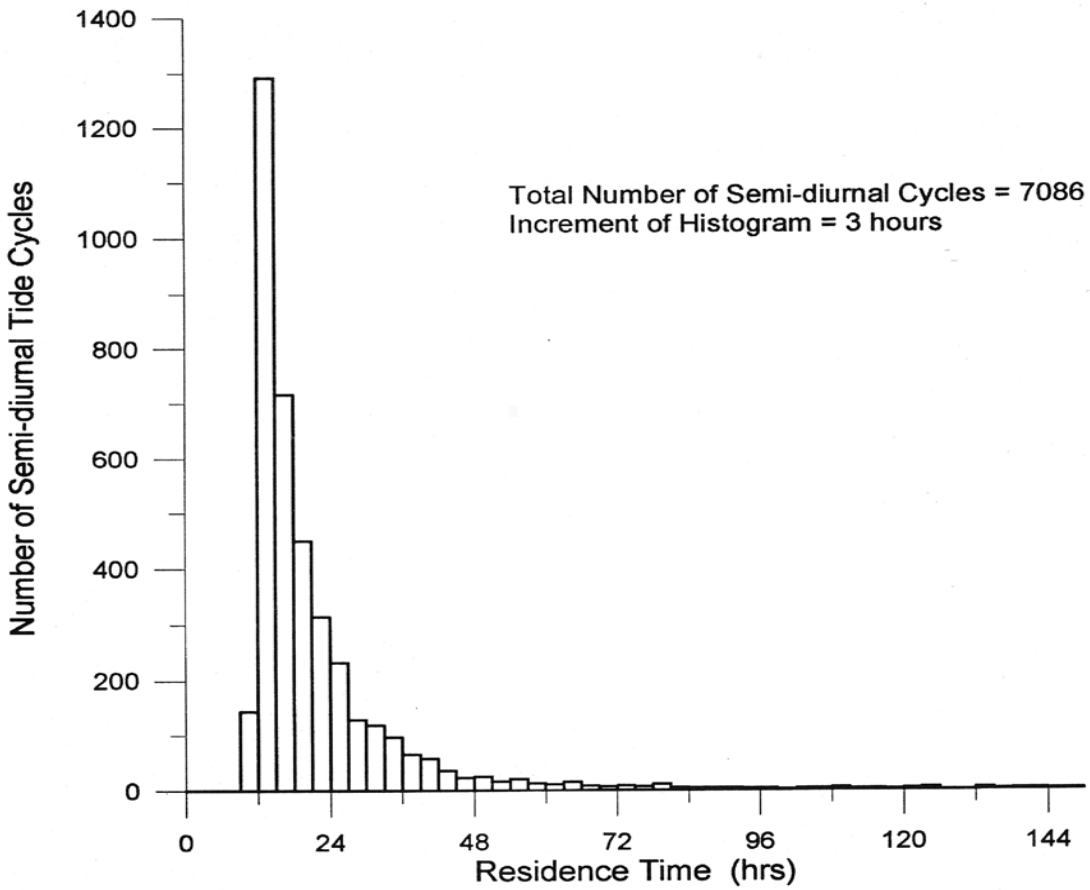


Figure 5-9. Hydroperiod Function for Preferred Restoration Alternative at Tijuana Estuary



[a]Based on open inlet configuration

Figure 5-10. Residence times for the Preferred Alternative B main tidal basin, using historic ocean level forcing, Tijuana Estuary

5.3.6 Simulations of Tidal Sediment Influx

In this section, the sediment influx rate of the preferred restoration alternative will be compared with the sediment influx rate of the existing estuary system. Figure 5-11 demonstrates that with each tide cycle there is a sharp influx of several hundred cubic yards of sediment on flood tide, followed by a partial flushing of that influx volume during ebb tide. However, ebb flushing does not expel all of the flood influx, and a net increment of influx remains upon completion of the tide cycle. Although the influx and outflux spikes are actually greater with the restoration plan in place, the net transport into the estuary will ultimately be reduced due to an increase in the total tidal prism (Figure 5-11). Therefore, the preferred restoration alternative will reduce the sedimentation rate of the main channel.

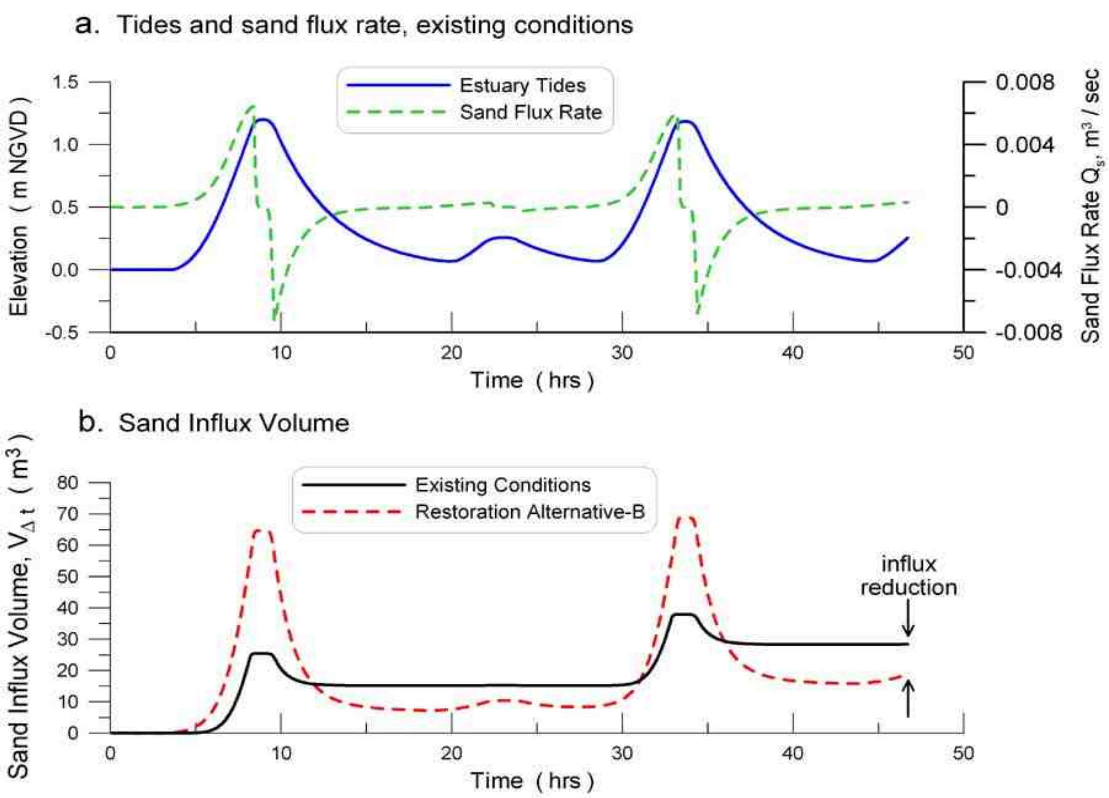


Figure 5-11. a) Tidal basin tides and sand flux rates for existing conditions; b) cumulative sand influx volume during spring tides existing conditions vs. Preferred Alternative-B, Tijuana Estuary.

In a 31 day simulation, the present estuary system accumulated 1,400 cubic meters of littoral sands versus 600 cu. m. in the system when the fully constructed restoration is added, a 57 % reduction (Figure 5-12). The primary cause of the higher net accumulation of littoral sediments under the existing system is the smaller ebb tide flushing. With the restoration, a greater fraction of the influx is expelled from the main channel. This action also maintains a deeper channel depth and allows more complete drainage of the entire system during ebb flow. As a result, the intertidal habitat will expand to elevations below mean sea level, down to as low as -1.0 ft NGVD (Figure 5-9).

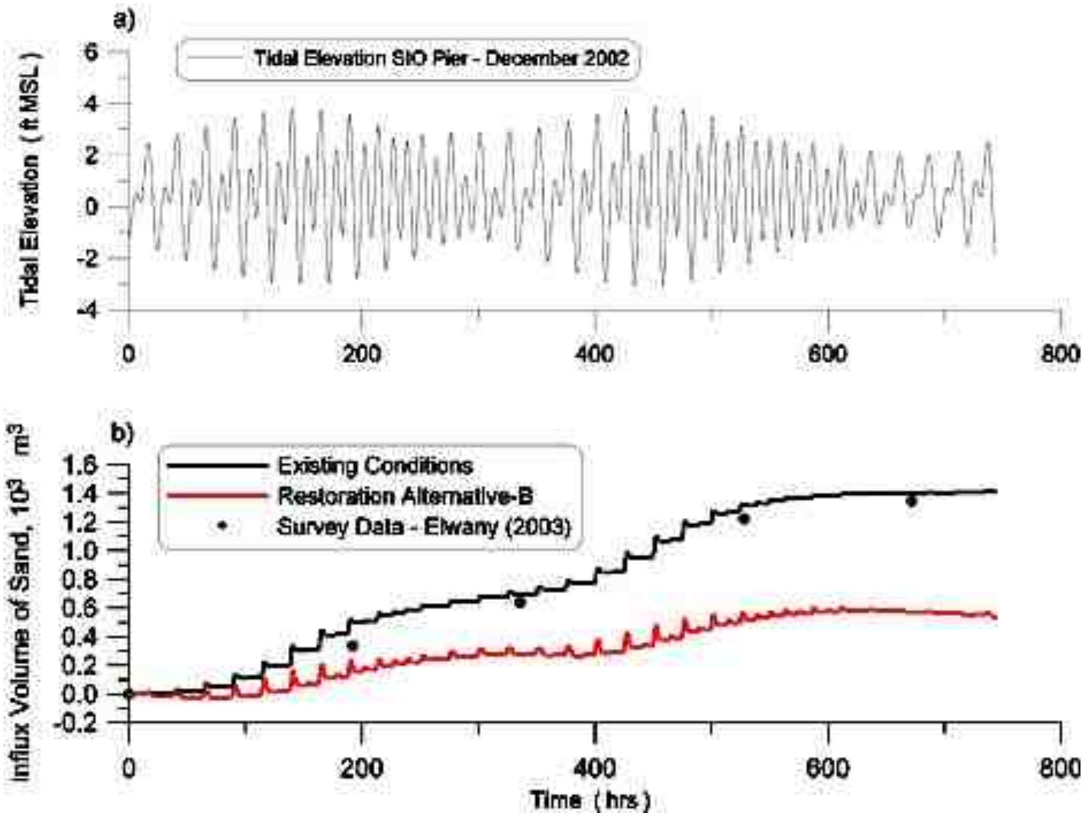


Figure 5-12. a) Tidal elevations, b) Cumulative sand influx volume at Tijuana Estuary. Modeled results for existing conditions , vs. Preferred Alternative-B

The net effect of the restoration on tidally induced sediment transport not only increases the lifespan of the system by reducing sedimentation, but improves the quality of habitat in the meantime. At the rates of reduction in channel sedimentation shown in Figure 5-11, the inlet channel should be able to sustain tidal exchange for a period of at least 47 months (almost 4 years) in the absence of any river scour due to floods. This self-sustaining period may in fact be much longer.

While restoration improvements increase tidal prism of the total estuary system by more than a factor of 2, sediment friction effects will produce a combined tidal prism of 1100-acre ft. during spring tides (Table 5-3). Although about 1,600 acre ft. of potential prism is needed to maintain the inlet by tidal flushing alone, this difference in volume may not be statistically significant.

5.3.7 Amplitude Errors

Due to the intermittent nature of rainfall in the Tijuana River watershed and the resulting relatively brief periods of fresh water dominance in the lower floodplain, Tijuana Estuary remains a tidally dominated system throughout most long-term periods of record. For this reason, issues of salinity stratification interfering with tidal exchange functions are minimal in this analysis.

In these simulations, limited data, sea level anomalies, iteration errors and a host of other factors can introduce error into the model predictions. In this analysis the maximum high tide error in the model simulation relative to observations was consistently found to be approximately = -0.13 ft. When amplitude errors do occur they tend to over estimate the water elevation of the lowest tidal stage, and under estimate the water elevation of the highest tidal stage. To ensure confidence in predictions, all model calibrations are designed to minimize or eliminate exaggeration of model predictions.

5.4 The Preferred (Alternative B) Restoration Alternative

Progressive loss of beach width and breaching of the barrier sand spit that protects the estuary can be significantly reduced by the proposed wetlands restoration. This plan will achieve tidal inundation of up to 250 acres of new wetland habitat. This figure includes 61 acres of sub-tidal habitat, 61 acres of mud flats, 60 acres of low marsh, 61 acres of mid and high marsh, and 7 acres of transitional habitat. The tidal prism of the newly created wetlands alone will be about 420-acre ft. volume, increasing the tidal prism of the entire Tijuana Estuary system to about 750-acre ft. This represents a factor of 2.3 increase over the existing tidal prism, restoring it to about half of it's historic maximum of 1,550 acre-ft. as estimated using the USCGS map prepared in 1852. This increase of tidal prism will greatly reduce in-filling of the main river channel by beach sediment and naturally increases the residence time of these sediments in the existing beach system. By increasing the tidal prism, the restoration will reduce littoral sediment influx rates by 57%, bringing the estuarine system close to self sustaining equilibrium based on the long term wave power incident in the Silver Strand littoral cell. The restoration will also greatly reduce beach retreat rates.

5.4.1 Restoration Maintenance

Unfortunately, increases in tidal prism are insufficient to flush all sediments entering the newly created wetlands from nearby canyons. These sediments currently present a persistent annual dredging requirement with inputs from Goat Canyon alone potentially delivering 55,000 cubic yards of sediment per year. The construction of sediment retention basins in Goat Canyon are expected to alleviate much of this potential sediment influx, but cannot accommodate the potential for catastrophic sediment-delivering flood events. In addition, other canyons adjacent to the estuary without sediment controls could pose a threat to the restoration in the future.

To avoid the environmental damage of conventional sediment dredging, a fixed-place bypassing system comprised of buried fluidizer pipes is proposed for the subtidal channels and basins of the restoration (Figure 5-13). The fluidizer pipe is merely a long plastic pipe with a line of small holes at 6-inch intervals along its length. The pipe lies in the bottom of the tidal channel and is accessed by a mobile pump system as needed. When sediments accumulate in the channel or lagoon, water is pumped through the pipe to liquefy the sediments in the immediate neighborhood of the fluidizer pipe. When this action is coordinated with ebbing tide, the resulting slurry of sediments are readily transported in the ebb tide flow direction to a collection basin and subsequently to a major self scouring river channel the open ocean.

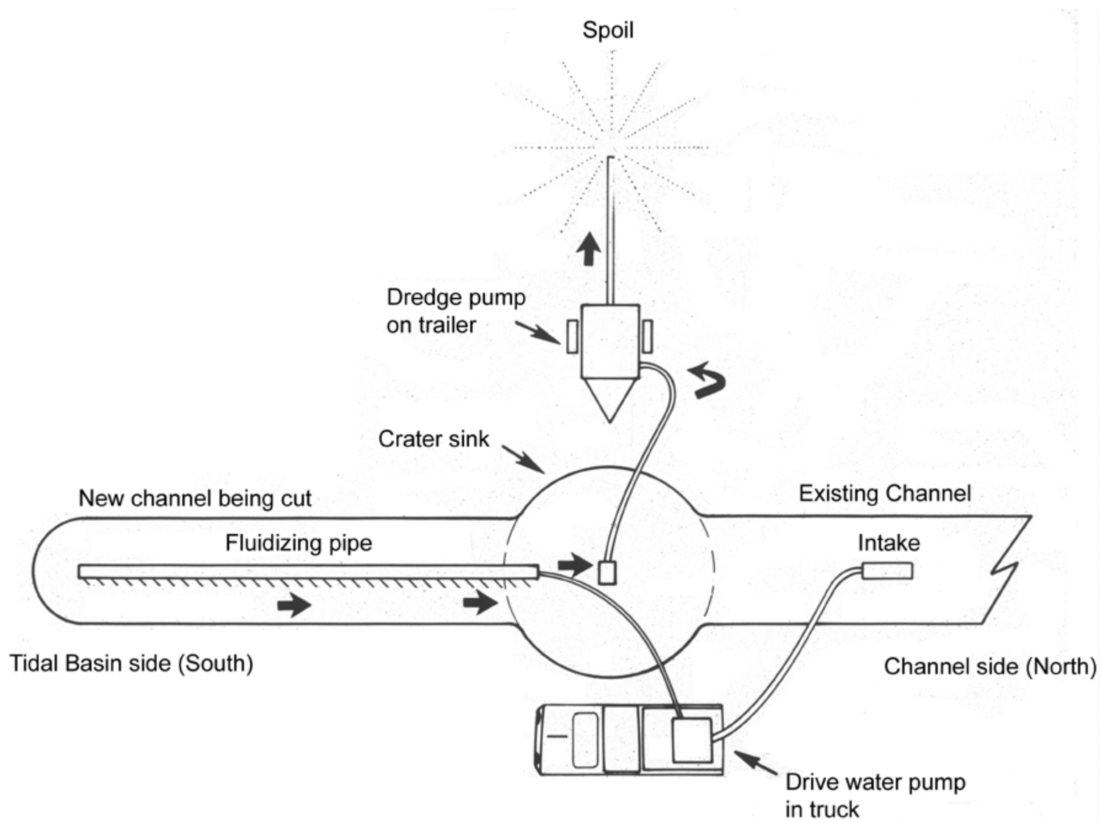


Figure 5-13. Schematic of the fluidizer maintenance system

This type of system was successfully tested at Los Peñasquitos Lagoon and the engineering details were reported in Jenkins, et. al (1980, 1992). Results from these trials suggest that if this system were operated 4 times per week at Tijuana Estuary during ebbing tide, it could evacuate all of the 55,000 cubic yards of Goat Canyon sediment from the proposed main tidal basin in a 4-month period (see Section 11.0 Project Phasing and Construction Alternatives). The relatively simple structure and mobility of the fluidizer system is also well suited to handle periodic influxes of sediment from unexpected sources. In all situations, this maintenance effort should only be necessary during wet-weather months.

A schematic of the fluidizer maintenance system proposed for this project is shown in Figure 5-14. Operation of the mobile fluidizer system is additionally valuable because it will deliver sediment to the beach, further offsetting long-term losses of beach width. When the sediments potentially transported by the fluidizer system are added to the beach evolution model, the predicted beach retreat rate would be further reduced (Figure 5-15). This unique sediment transfer, resulting from estuary restoration maintenance, should help delay adjacent beach breaching and may play an important role in the preservation of the existing barrier beaches at Tijuana Estuary.

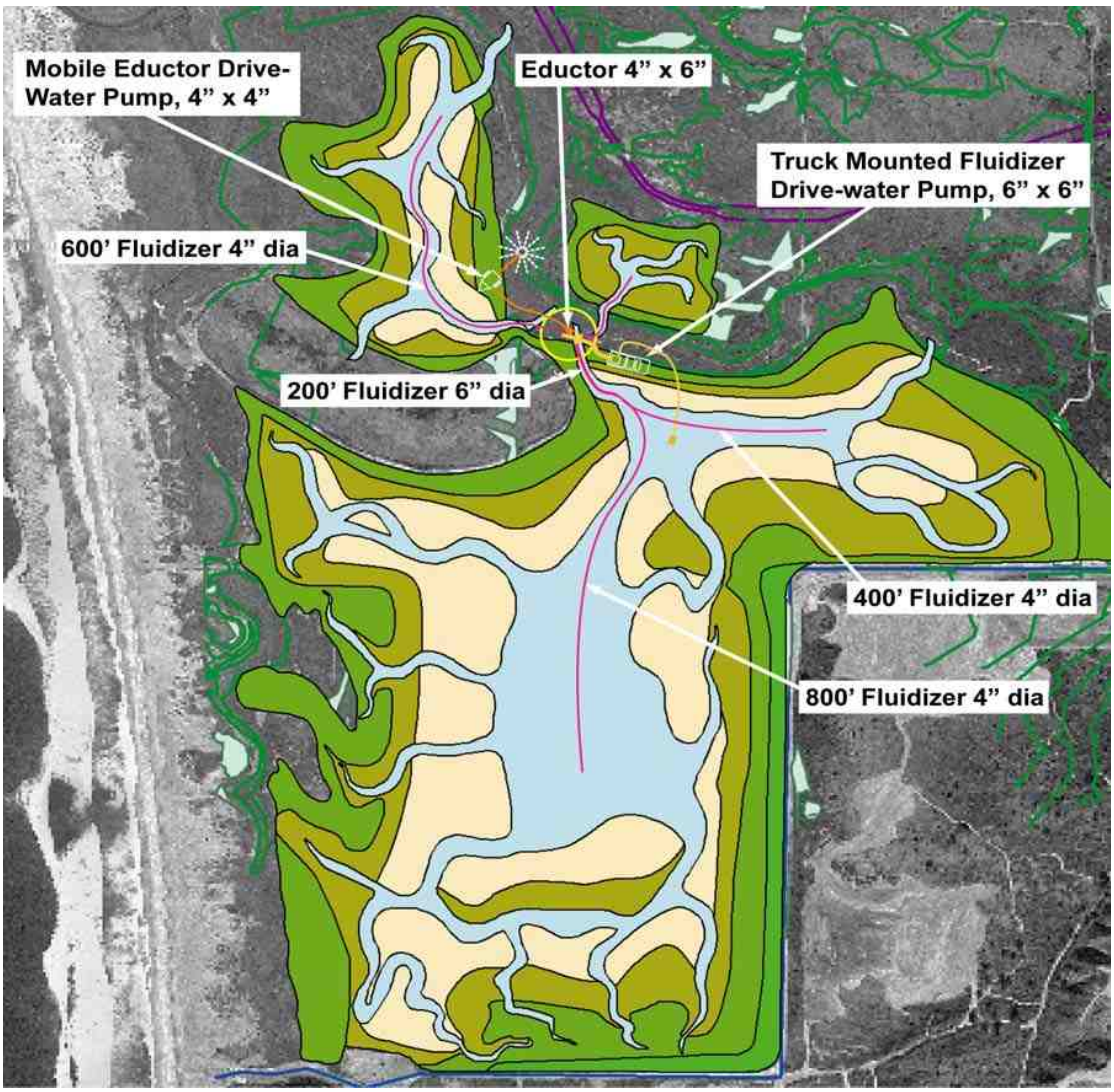
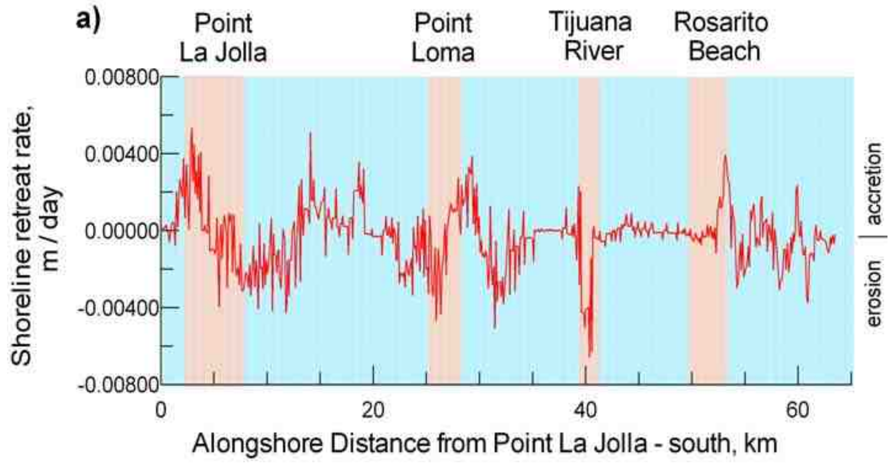


Figure 5-14. Fluidizer maintenance system within the Preferred Restoration Alternative B



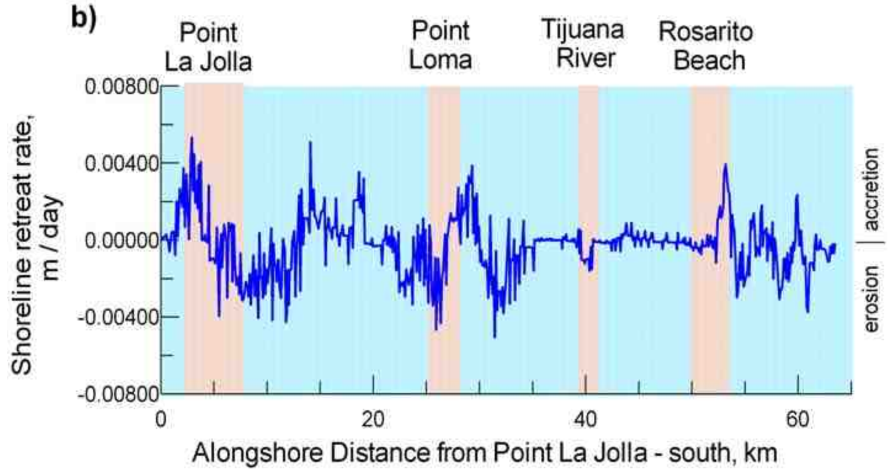


Figure 5-15. Predicted shoreline retreat rate for: a) No-Project alternative, and b) Preferred Restoration Plan B

5.5 Conclusions

This two-part study addresses several potential impacts which a restoration of Tijuana Estuary may have on the coastal processes of the neighboring littoral region. Part I of this study evaluates ongoing beach retreat in the lower Silver Strand Littoral Cell and its effects on the life span of the existing estuary. This section also discusses the potential for a wetlands restoration excavation to release beach sediment that is presently impounded in the inlet channel system of the estuary. Part II evaluates the tidal hydraulics of the preferred restoration plan. This analysis calculates tidal ranges and elevations in the newly created tidal basins and marsh plains, hydro-period function, channel velocities, sediment fluxes, and habitat breaks affecting construction and maintenance requirements.

Analysis concludes that under existing conditions the beach retreat rates will result in long-term erosion and eventual breaching of the barrier sand spit that protects the ocean frontage of the estuary system. The time horizon for this eventual outcome under the *No-Project Alternative* is about 2045. The consequences of such an outcome will not result in complete and instantaneous destruction of the Tijuana Estuary. Rather, it will add another mechanism of gradual estuary degradation through accelerated channel sedimentation and reduction of tidal inundation. These effects will be most pronounced during dry climate.

6.0 TIJUANA RIVER FLOOD HYDROLOGY, EROSION AND SEDIMENTATION

The hydrology, erosion and sediment dynamics of the Tijuana River were modeled for the current project by Dr. Howard Chang of Chang Consultants. This summary was prepared by Tierra Environmental Services (Tierra) and any errors are the responsibility of Tierra. Dr. Chang's report is presented in its entirety in Appendix B.

6.1 Introduction

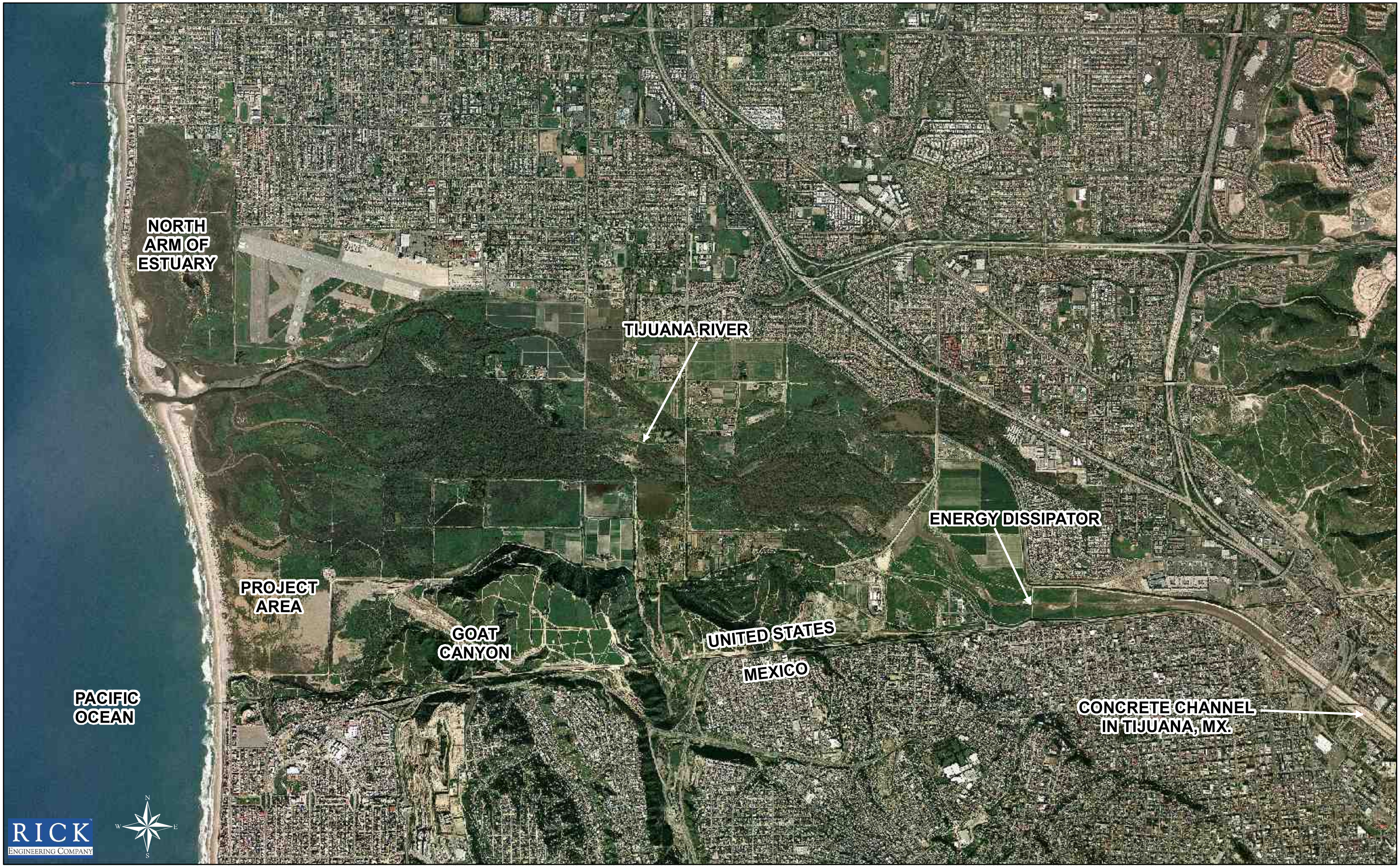
The Tijuana Estuary Friendship Marsh Restoration Feasibility and Design Project is located south of the current main channel of the Tijuana River and adjacent to the Model Marsh. In the last century, the Tijuana River has been severely disturbed by human activities. Physical modifications to stream channels include upstream dams, channelization in Mexico, sand and gravel channel mining, and flow dissipation devices. These features alter watershed function and result in a dynamic river channel system with the potential to affect the restoration project.

6.1.1 Major Watershed and Channel Characteristics

The Tijuana River drains about 1,700 square miles, 73% of which lies in Mexico. Three reservoirs regulate 71% of the total drainage area. These are Morena and Barrett Reservoirs within the U.S. (combined capacity of 96,000 acre-feet) and the Rodriguez Dam in Mexico (capacity of 110,000 acre-feet). Other dams are planned within Mexican portions of the watershed (Pombo 2000). Below these dams, and throughout the watershed, channels flow through both natural and human-modified landscapes, including the city of Tijuana, Mexico. In urban Tijuana, the river also flows for many miles in a concrete channel until it reaches the international border. Immediately upon the U.S. side of the border, the river enters an energy dissipater system before reaching Tijuana Estuary, and, finally the Pacific Ocean (Figure 6-1).

The Tijuana River Watershed is an intermittent watershed typical of semi-arid areas (Pryde 2004). Precipitation is seasonal and extremely variable, with the majority of rain events occurring in the winter, between November and April. Precipitation is sometimes delivered in intense storms lasting only a few days (Wright 2005). In contrast, for most of the summer and fall, precipitation and stream flow is normally absent.

Since 1980, human activity has resulted in abnormal perennial flows in the lower Tijuana River. These are primarily the result of Rodriguez Reservoir leakage coupled with renegade sewage flows from the city of Tijuana. These flows, in turn, have produced a seasonally variable freshwater aquifer (PWA 1987). Millions of gallons of untreated sewage have crossed the international border via the Tijuana River. These flows also emanate from north-trending tributary canyons, particularly Goat Canyon and Smuggler's Gulch. The construction of sewage interceptors in these north-trending canyons and the construction of the International Wastewater Treatment Plant in 1999 has reduced the flow of sewage to the estuary and ocean. However, during the winter rainy season, untreated sewage still flows across the international border into Tijuana Estuary and the Pacific Ocean.



Lower Tijuana River Watershed Features

FIGURE 6-1

During the winter and spring, the Tijuana River can produce severe flooding. Such spring floods have occurred in 1980, 1983, and 1993, with devastating physical effects on natural habitats and infrastructure in the Tijuana River Valley. Some urban tributaries of the Tijuana River, such as Goat Canyon and Smuggler's Gulch, are especially subject to flash flooding during heavy rainfall events (Wright 2005).

The three reservoirs within the Tijuana River watershed were designed for water storage and have only limited capacity for flood control purposes. Rodriguez Dam, equipped with floodgates on the spillway, is capable of regulating a major flood to a certain extent. The other reservoirs control most smaller storm flows in the upstream portions of the watershed. The most significant effect of the reservoirs is to detain the majority of the bed sediment in the system. This results in a sediment deficit in all downstream segments.

The balance between sediment supply and transport produces the dynamic equilibrium of the river channel. Because the water overflowing the dam spillways is depleted of all heavier bed sediments, the river will attempt to return to equilibrium by removing similar sediments from the downstream channel boundary. This removal process is called scour.

The influence of dams also interrupts natural sediment distribution within the watershed. Normal distributions result in a slight decrease in sediment grain size moving from the upper floodplain of the river toward the river mouth. The lower Tijuana River bed holds clay, silt, sand and gravel, but the dominant bed material is sand. Soil investigations and grain size distributions are presented in detail in Section 8.0 Substrate Characteristics in the Project Area.

6.1.2 Estuary Characteristics

Dynamic processes within the Tijuana River estuary include:

- Flushing and meandering of the river channel during storms; and,
- Recharge of the estuary by littoral sand during tidal exchanges in the dry season.

Tijuana Estuary currently has a small tidal basin at the inlet channel. Bed sediments are transported either from the river channel through the inlet channel by storm flows or from the ocean to the estuary by tidal exchanges. River flood flows result in a net export (flushing) of bed material from the inlet channel while tidal exchanges usually result in net sediment import to the inlet channel. As a result, many estuary inlet channels in semi-arid regions undergo episodes of opening and closure. Since the water quality in the estuary is closely related to the opening of the inlet channel, the opening duration is important to environmental assessment and planning.

The proposed marsh restoration is located in the floodplain of the Tijuana River south of the main channel and may have important hydrological impacts on the river channel, including:

- flood level,
- river channel scour, and
- sediment delivery to the beach.

In order to evaluate these impacts on the Tijuana Estuary, it is necessary to apply an erodible boundary model capable of simulating river hydraulics, sediment transport and river channel morphology changes. In addition, other river channel features including bed materials, flood hydrography, gravel extraction sites, and hydraulic structures can be significant.

6.2 Flood and Channel Data

Flood discharges for the 100, 50 and 10-year floods adopted by the Federal Emergency Management Agency (FEMA) are used in this study (Table 6-1). A 25-year flood figure is calculated from the log-probability distribution of other floods.

Table 6-1. Flood Discharges for the Tijuana River

Flood event	Peak Discharge (cfs)
10-yr	17,000
50-yr	50,000
100-yr	75,000

6.3 Effective and Ineffective Flow Area

The Tijuana River has been confined to a single channel that meanders across a broad floodplain. Flow velocities within the system are naturally higher within the main channel than in the overbank areas. Flow velocities are also significantly affected by bridges, road crossings and existing berms within the floodplain. Areas behind the berms may occasionally experience minor flow and be under water during an extreme flood, but these areas do not contribute significantly to the conveyance of the flow discharge. In hydrologic terms, these areas are described as being outside of the effective flow area. Figure 6-2 shows the lower Tijuana River with a line delineating the effective flow area and the ineffective flow area. The linear structure east of Section 77.5 is the existing AmSod berm. From Section 77.5 toward Section 45.0, the effective flow expands in width, and then converges toward the opening at the river mouth.

Channel geometry at selected points of the lower Tijuana River between the river mouth and the energy dissipater is shown in Figure 6-3. (Figure is dissected in three frames).

6.4 Bridge Hydraulic Effects

The lower Tijuana River has two bridge crossings at Hollister Street and Dairy Mart Road, respectively. The proposed project is far enough from these bridges to have no effect on adjacent river flow or sediment transport.

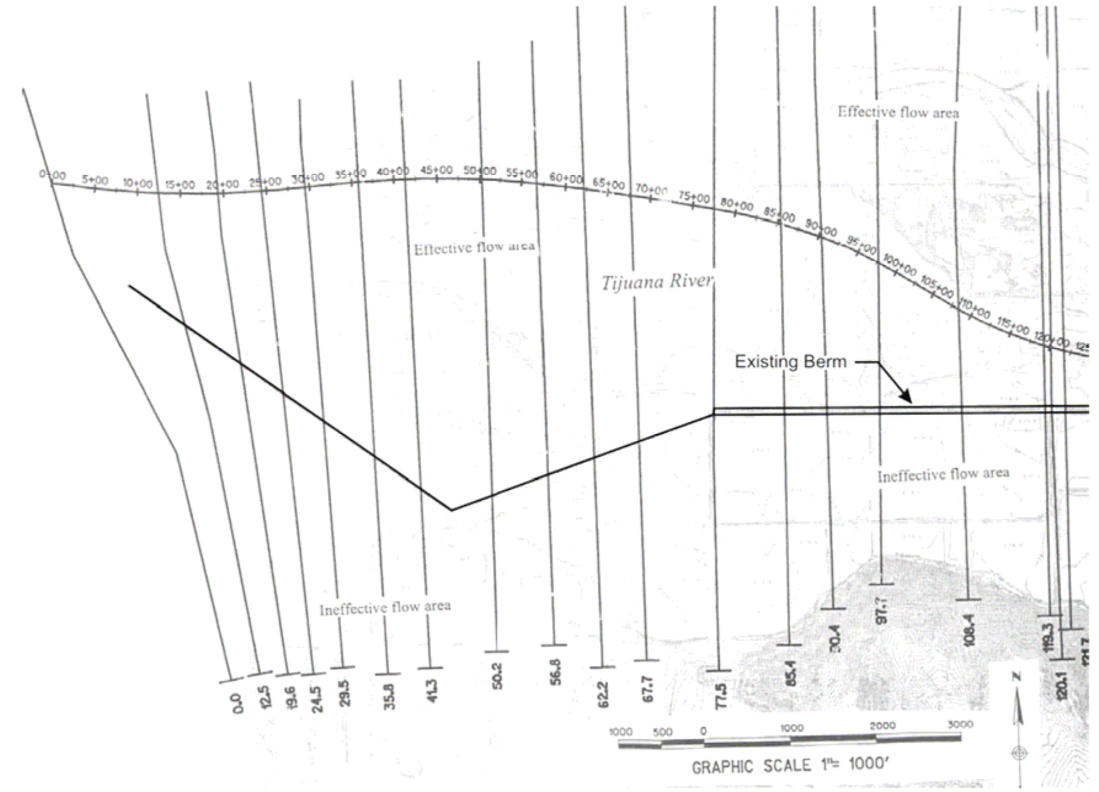


Figure 6-2. Lower Tijuana River Showing Effective Flow Area with Existing and Proposed Berm

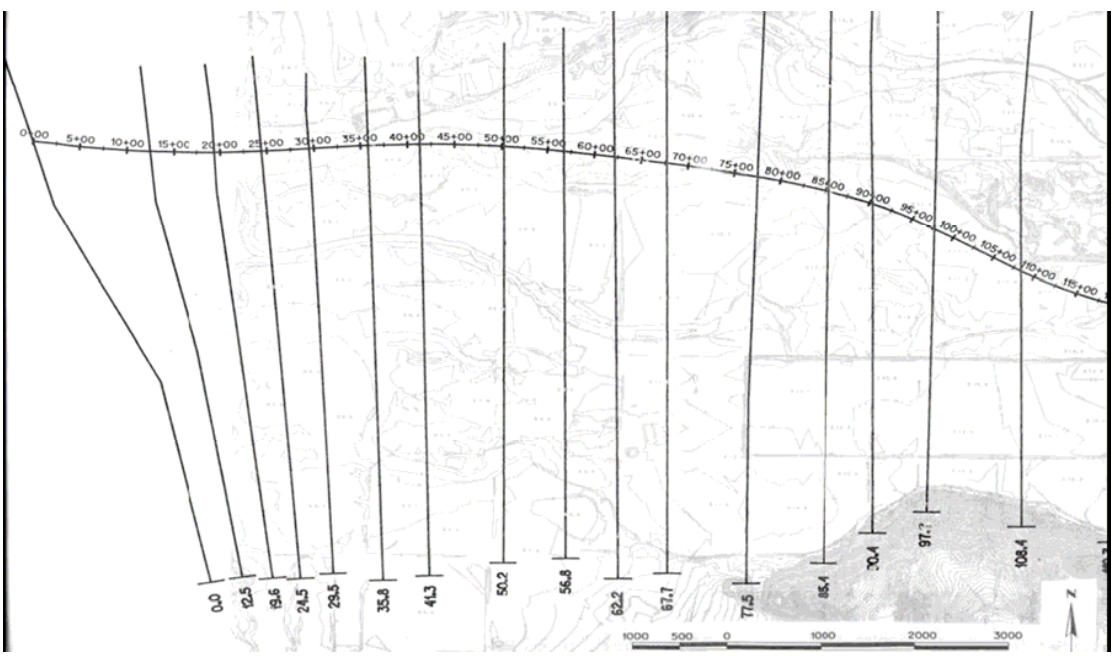
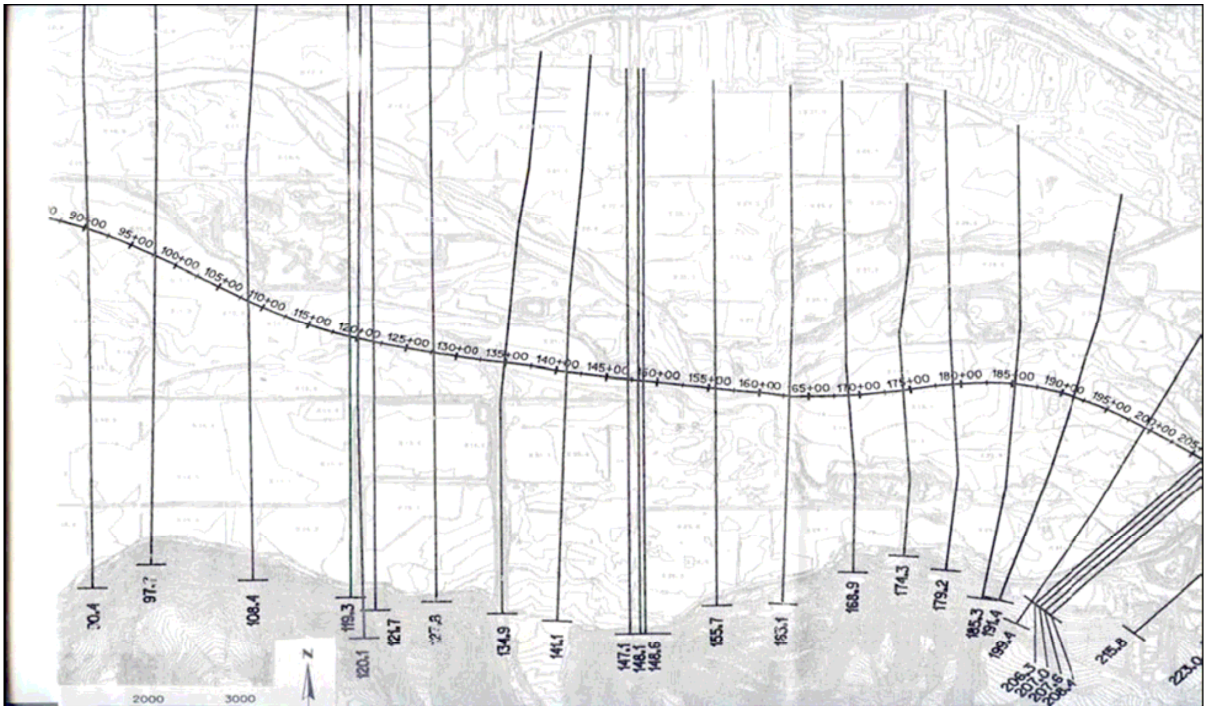


Figure 6-3. Channel Geometry of the Lower Tijuana River at Selected Cross Sections



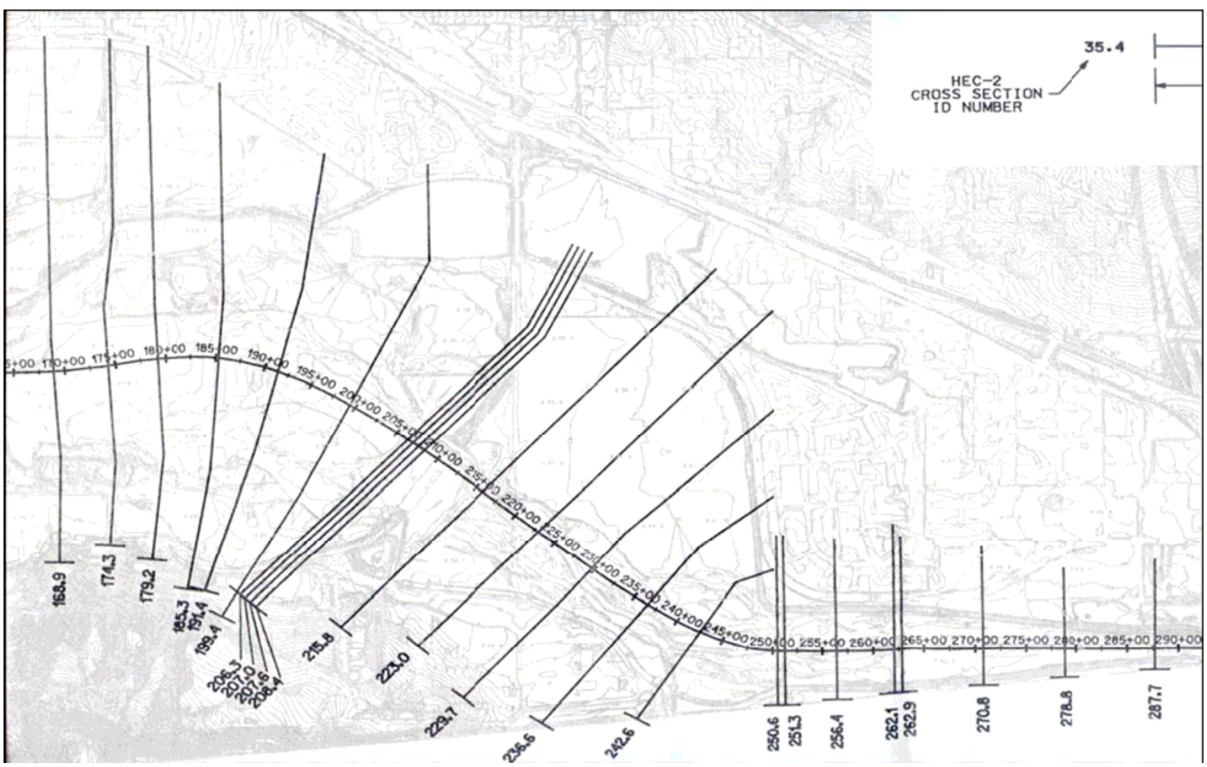


Figure 6-3 (continued). Channel Geometry of the Tijuana River at Selected Cross Sections

6.5 Stream Scour and Sediment Deposition

Stream channel scour consists of general scour and local scour. General scour is determined by the volume of coarse sediment supplied to the river channel. Local scour results from flow interaction with a local obstruction, such as a bridge pier or abutment. Sediment delivery in the stream channel is in turn related to the flood height, channel geometry, and sediment characteristics in the system.

6.5.1 Mathematical Model for General Scour

The FLUVIAL-12 model (Chang 1988) simulates spatial and temporal variations in water-surface elevation, sediment transport and recharge including scour of the streambed. Scour and fill of the streambed by sediment are coupled with channel width variation to predict changes in channel size and width. The model simulates changes in the channel geometry based on a stream's tendency to balance sediment discharge and power expenditure. At each time step, scour and fill of the channel bed as well as channel width changes are calculated. Computations are based on energy and mass conservation principles representative of unrestricted channel flow. Details of the FLUVIAL-12 model are presented in Appendix B.

6.6 Hydraulic Design of the Berm and Weir for Marsh Protection

The Friendship Marsh Restoration Project will be constructed by lowering the elevation of the project area. Due to this lowered elevation, the restored marsh area will be subject to both greater flooding and higher sediment influx rates than the surrounding area. These effects could potentially result in impacts to the constructed wetland.

In order to protect the restored marsh from potential damages caused by flow and sedimentation, a berm is proposed to separate the restored marsh from the effective flow area of the river channel (Figure 6-4). The berm is designed to keep both high flows and bed sediment from entering the restoration area.

The alignment and design of the berm were determined by many trial modeling runs. An alignment that encroaches on the river flow could cause a rise in the flood level (backwater effects). On the other hand, an alignment outside the effective flow area would limit the area available for marsh restoration. Fortunately, backwater effects can be eliminated if a portion of the higher river flows is admitted into the marsh area through a weir. This would allow the berm to be aligned within the effective flow area.

The berm must be constructed with cohesive earth materials containing sufficient silt and clay content. Sandy materials should be avoided. The berm and weir structure must also be armored and hardened for adequate erosion protection.

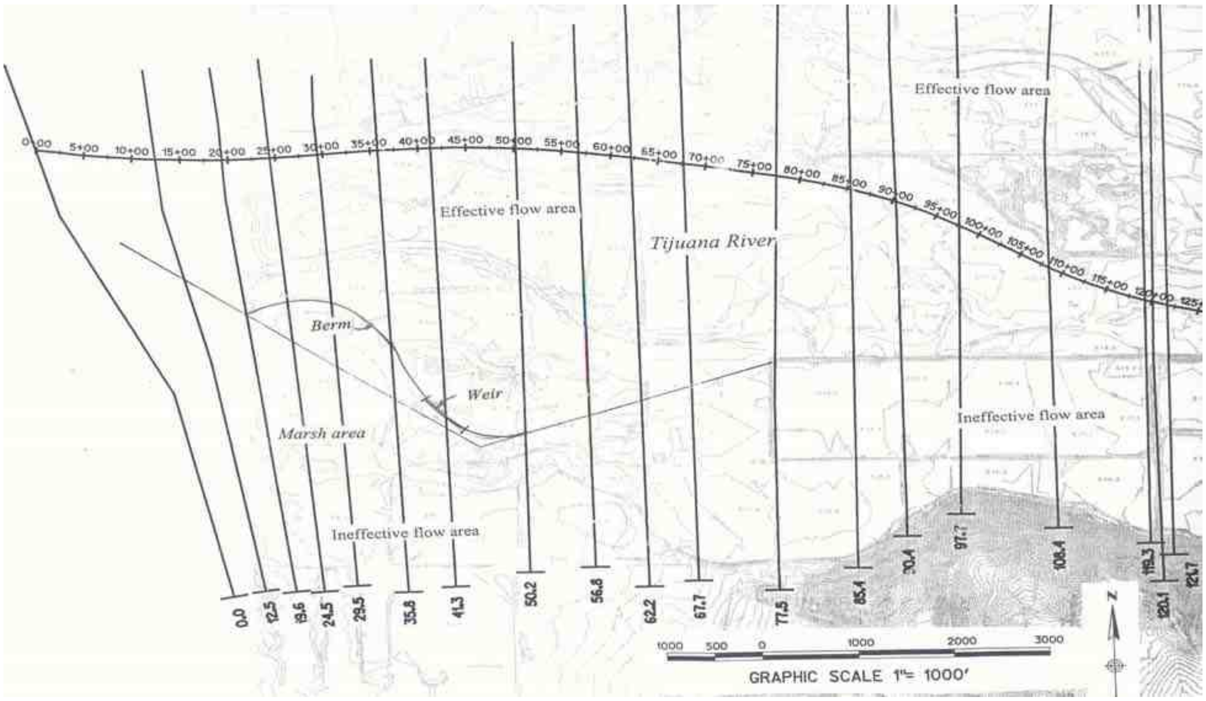


Figure 6-4. Lower Tijuana River Showing the Proposed Berm Alignment

The proposed weir would be located on top of the berm and centered at section 41.3. It would include the following features:

1. Crest length: 700 feet.
2. Crest elevation: Varies from 7.3 feet at the west end to 7.6 feet at the east end.
3. Side slope: 3:1.
4. Armoring of weir and berm against potential erosion

In order to maintain a low visual profile for the berm, the top berm elevation will be one foot lower than USACE guidelines for the 100-yr flood level. This slightly lower height is acceptable because there are no insurable structures in the marsh behind the berm.

6.6.1 Effects of Weir Flow on the Restored Marsh

The weir would perform the following functions:

1. Only floods higher than the 10-year flood level will enter the marsh area because the weir crest elevation (approximately 7.5 ft.) corresponds to the 10-year flood level.

2. A small portion of higher floodwaters would leave the main channel and enter the marsh area to relieve backwater effects on the river channel (Table 6-2). This partial flow has a maximum discharge of 14,600 cfs during the 100-yr flood (19.5 % of the 100-yr discharge for the river channel). As the flow enters the marsh area, it would spread out

over a very large surface area and the average flow velocity in the marsh area would quickly drop below 3 feet per second. This velocity is considered to be a non-scouring velocity and, therefore, will not cause damage to the vast majority of marsh habitat.

3. No bed sediment will enter the marsh area beyond the berm because the weir crest elevation is above the adjacent river channel bed.

Table 6-2. Flood Stage-Discharge Relations for River and Weir Flow

River stage (Feet)	H, Average head over weir crest (Feet)	Weir discharge (cfs)	River discharge (cfs)
7.5	0	0	17,000
8.0	0.5	765	19,500
8.5	1.0	2,160	24,000
9.0	1.5	3,980	32,000
9.5	2.0	6,130	43,000
10.0	2.5	8,570	50,500
10.3	2.8	10,170	58,000
10.5	3.0	11,280	64,000
10.7	3.2	12,430	70,000
10.9	3.4	13,610	72,000
11.1	3.6	14,810	76,000

Suspended sediment load and floating debris would be transported into the marsh during weir flows. However, this should not be a significant maintenance problem for the marsh for the following reasons:

1. Weir flow would occur infrequently, generally once every 10 years because the weir will exclude all but the highest flood flows.

2. The duration of weir flow would always be much shorter than the full flood duration. In addition, the volume of discharge over the weir would be very small during most of the overflow period.

3. Only the finest portion of the suspended sediment load (the wash load) can be carried into the marsh. This wash load comprises a very small volume and tends to remain in suspension for long periods of time. Therefore, it is most likely to remain in suspension and be transported directly through the marsh channels, back to the main river channel, and subsequently the Pacific Ocean.

Floating debris will occur in flood flows, but because of the typically low water depth passing the weir, most large debris is unlikely to pass into the marsh. Small pieces of debris that do enter the marsh may also float directly out again. Remaining amounts of debris should not be significant.

6.6.2 Summary of Berm and Weir Effects

The proposed berm will feature a weir to eliminate the backwater effects of the berm on the adjacent river channel. A small portion of the flood flow, but no significant sediment or debris would be diverted into the marsh through the weir. Modeled 100-yr flood water-surface elevations for the existing river channel with and without the berm and weir are very similar, with no backwater effects from the berm. The potential effects of weir flow on marsh sedimentation should be insignificant. Bed sediments will not pass the weir and the very small volumes of suspended sediment and floating debris that do pass, will likely be transported directly through and out of the marsh during weir flows.

6.7 Modeled Channel-Bed and Flood Water-Surface Profiles

Figures 6-5 and 6-6 show the simulated water-surface and channel-bed profile changes during a 100-yr flood for the existing and proposed conditions, respectively. These figures and Table 6-3 show that these two water-surface profiles are very similar with only minor differences. Flood flow removes sands accumulated during the dry season. After scour and sediment flushing in a flood, the inlet channel refills with beach sand due to littoral drift. During major floods, the channel reach within 3,000 to 4,000 feet of the river mouth is subject to significant scour which has the direct effect of lowering the flood level.

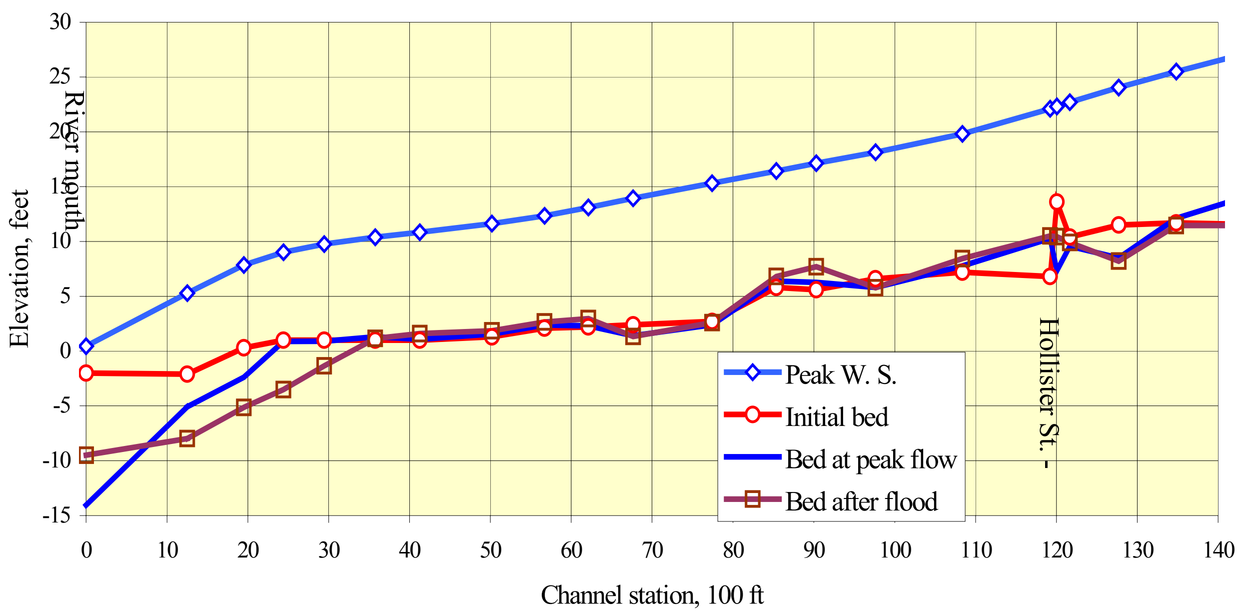


Figure 6-5. Longitudinal Profiles During 100-yr Flood for Existing Conditions

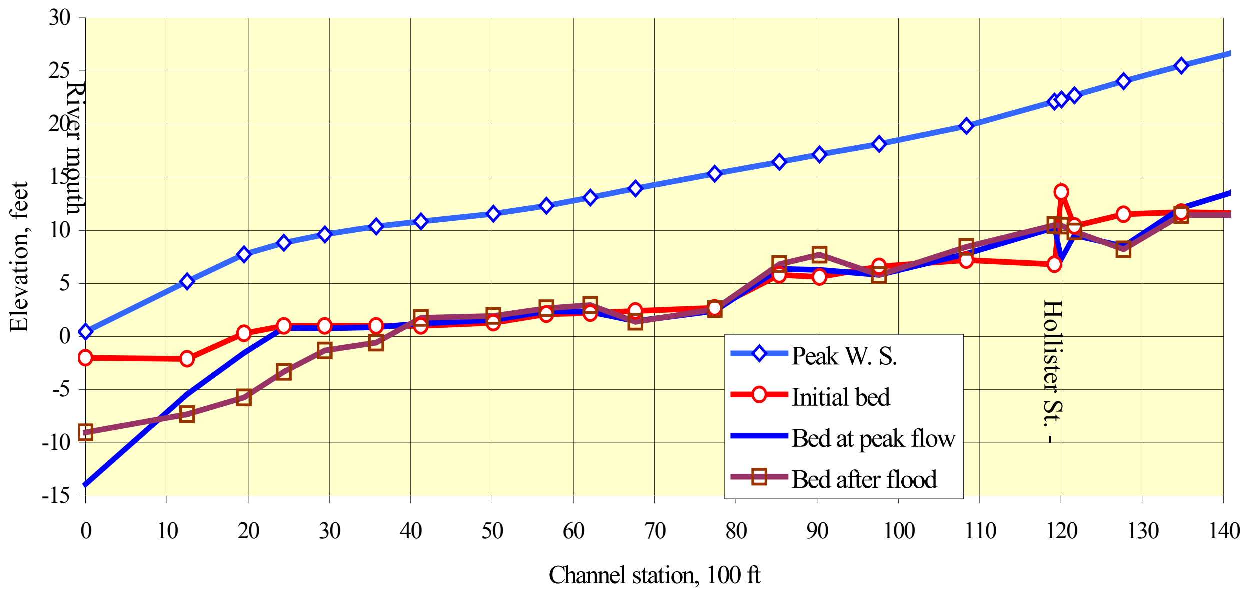


Figure 6-6. Channel Bed Profile Changes During 100-yr Flood for Proposed Conditions

Table 6-3. Computed Water Surface Elevations for 100-yr Flood Based on FLUVIAL-12 Model; Existing vs. Proposed Conditions

Section (100 feet)	Location	Computed water-surface elevation (feet, NGVD)	
		Existing conditions	Proposed plan
0.00		0	0
1.00	River mouth	0.5	0.5
12.5		5.3	5.2
19.6	Downstream limit of berm	7.9	7.7
24.5		9.0	8.8
29.5		9.8	9.6
35.8		10.4	10.4
41.3		10.8	10.8
50.2		11.6	11.6
56.8		12.4	12.3
62.2		13.1	13.1
67.7		13.9	13.9
77.5	Upstream limit of berm	15.3	15.3
85.4		16.4	16.4
90.4		17.1	17.1
97.7		18.1	18.1
108.4		19.8	19.8
119.3	Hollister Street	22.1	22.1
120.1		22.1	22.1
121.7		22.7	22.8
127.8		24.1	24.1
134.9		25.5	25.5
141.1		26.7	26.7
147.1		27.9	27.9

6.7.1 Velocity Changes Along the River Channel

The flow velocity is often used as a criterion to assess the potential for river channel scour. The cross-sectionally averaged velocities are included in the output of the FLUVIAL-12 model. Such velocities simulated at the peak 100-yr flood and their spatial variations along the river channel are shown in Figure 6-7 for the existing and proposed conditions. These spatial variations in velocity are useful to characterize the flow along the river channel. The figure shows that the river channel has very high velocities near the river mouth. These high velocities are responsible for the severe scour development reducing elevations at the river mouth shown in Figure 6-8.

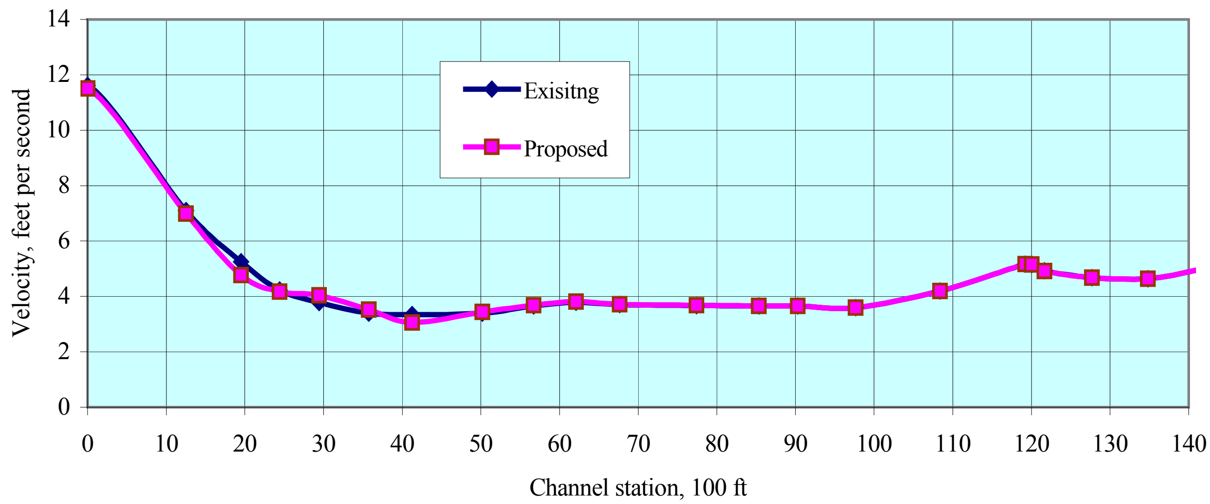


Figure 6-7. Spatial Variations in Velocity during 100-yr Flood

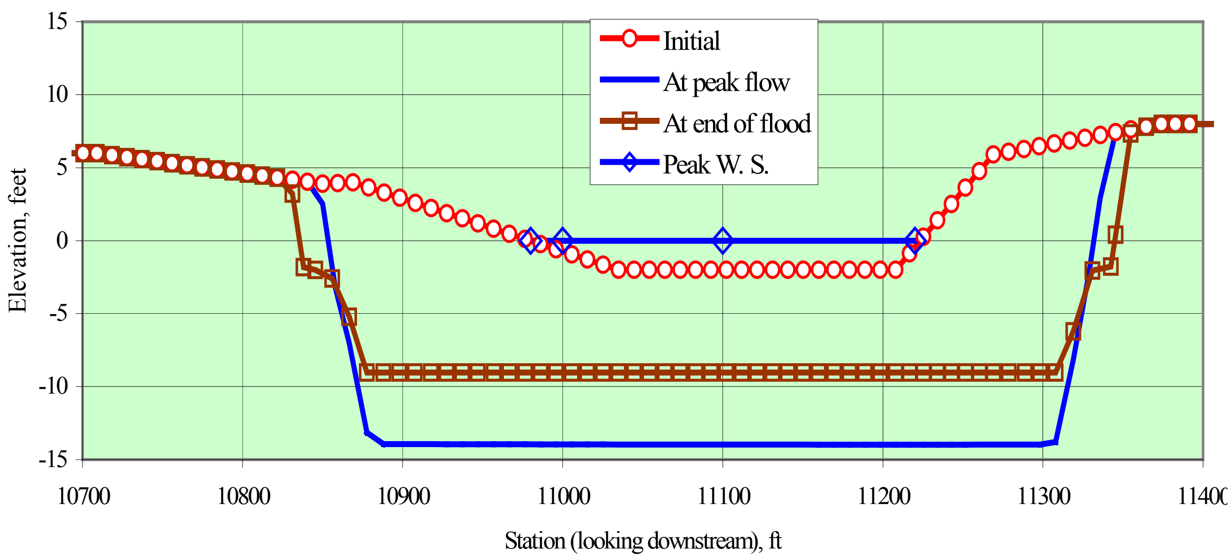


Figure 6-8. River Mouth Profile Simulating Scour: Before, During and After Flood

6.7.2 Net Scour Effects

The 100-yr flood was used to simulate sediment transport and stream channel changes for the lower Tijuana River under the existing conditions as well as under the proposed plan. Numerous cross sections of the river were analyzed and presented in detail in Appendix B. By comparing the simulated river channel changes for the existing and proposed conditions, it is clear that the proposed project will have insignificant effects on river channel scour.

6.7.3 Sediment Delivery and Beach Sand Supply

Spatial variations in sediment delivery are manifested as storage or depletion of sediment within a given portion of the stream channel. A decreasing delivery in the downstream direction (negative gradient for the delivery-distance curve) signifies a net deposition of sediment in the channel. On the other hand, an increasing delivery in the downstream direction (positive gradient for the delivery-distance curve) indicates sediment removal, or net scour. A horizontal line (zero gradient) indicates sediment balance (no storage or depletion). The restoration goal is to achieve dynamic equilibrium, the non-deposition and non-scour condition.

Figures 6-9 through 6-12, show spatial variations in sediment delivery during 10 and 100-yr flood stages for the existing and proposed conditions, respectively. These figures show that the restoration project will not significantly affect sediment distribution within the river channel. These figures show a general pattern of sediment removal, or scour, of the channel from channel station 40+00 to the river mouth. This scour contributes to beach sand supply. Sediment delivery from channel station 120+00 (Hollister Street) to channel station 40+00 shows a slight decreasing trend toward downstream. This indicates sediment deposition in the river channel.

The results for sediment delivery may also be used to assess the impacts of the proposed project on beach sand supply. Table 6-4 shows that there is no difference in beach sediment supply during the 10-yr flood between the existing and proposed conditions. However, the proposed project will result in a slight increase of beach sand supply during the 100-yr flood.

Table 6-4. Comparison of Beach Sand Delivery Rates; Existing vs. Proposed

Flood event	Total sediment delivery 1,000 tons	
	Existing	Proposed plan
10-yr flood	112	112
100-yr flood	990	997

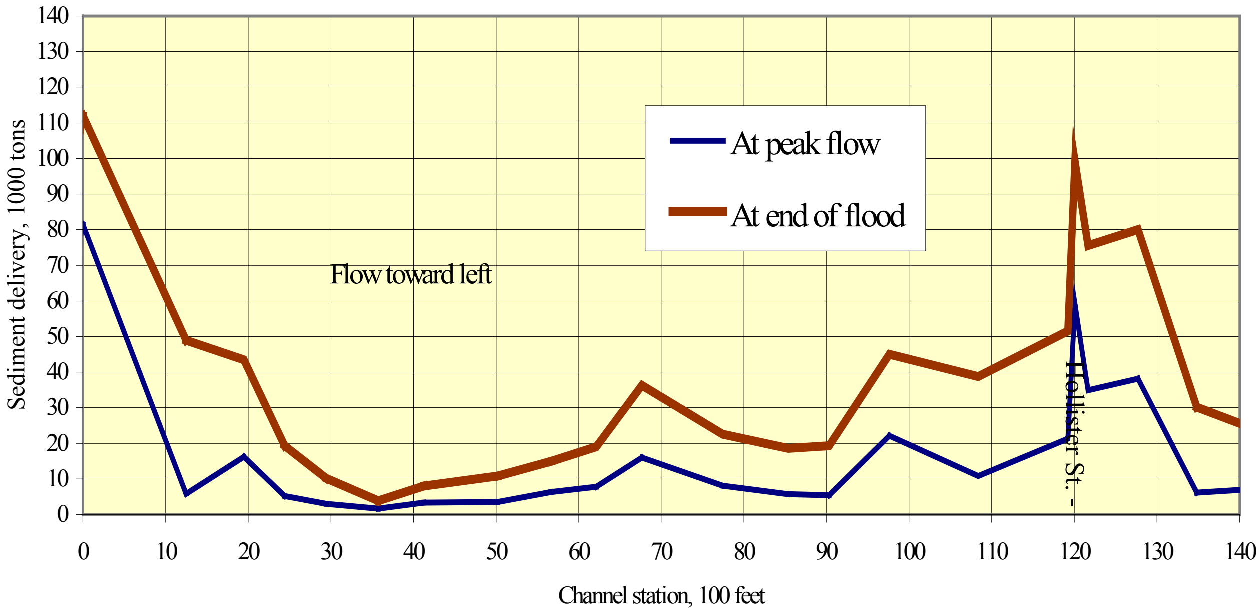


Figure 6-9. Spatial Variations of Sediment Delivery During 10-yr Flood for Existing Conditions

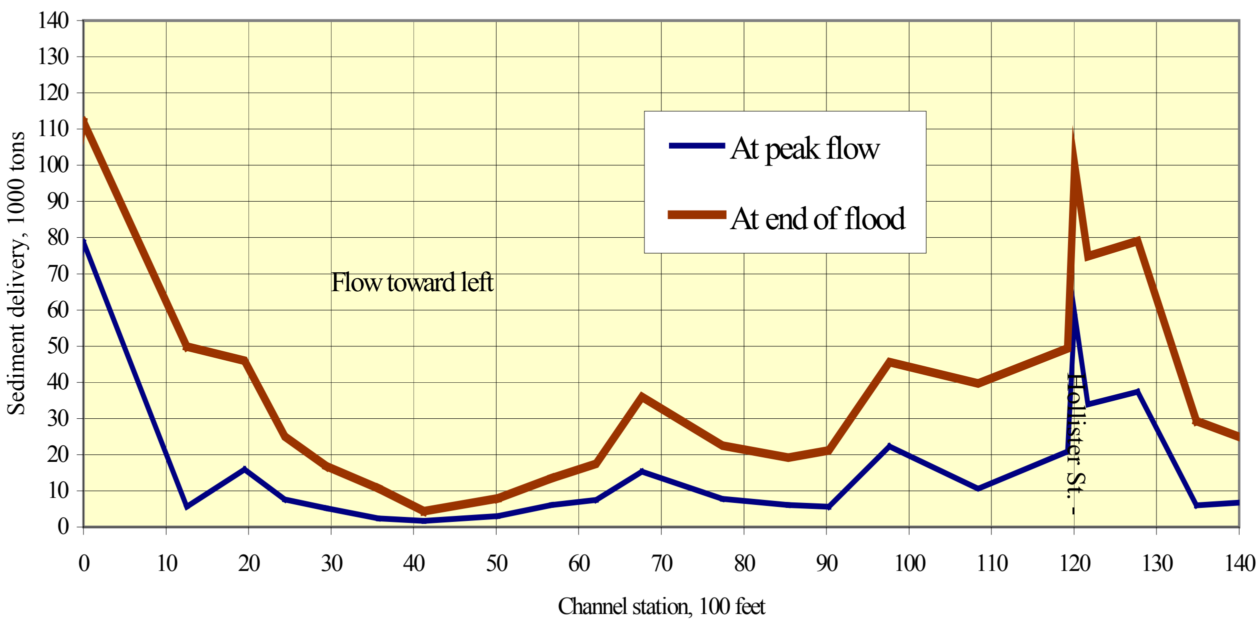


Figure 6-10. Spatial Variations of Sediment Delivery During 10-yr Flood for Proposed Conditions

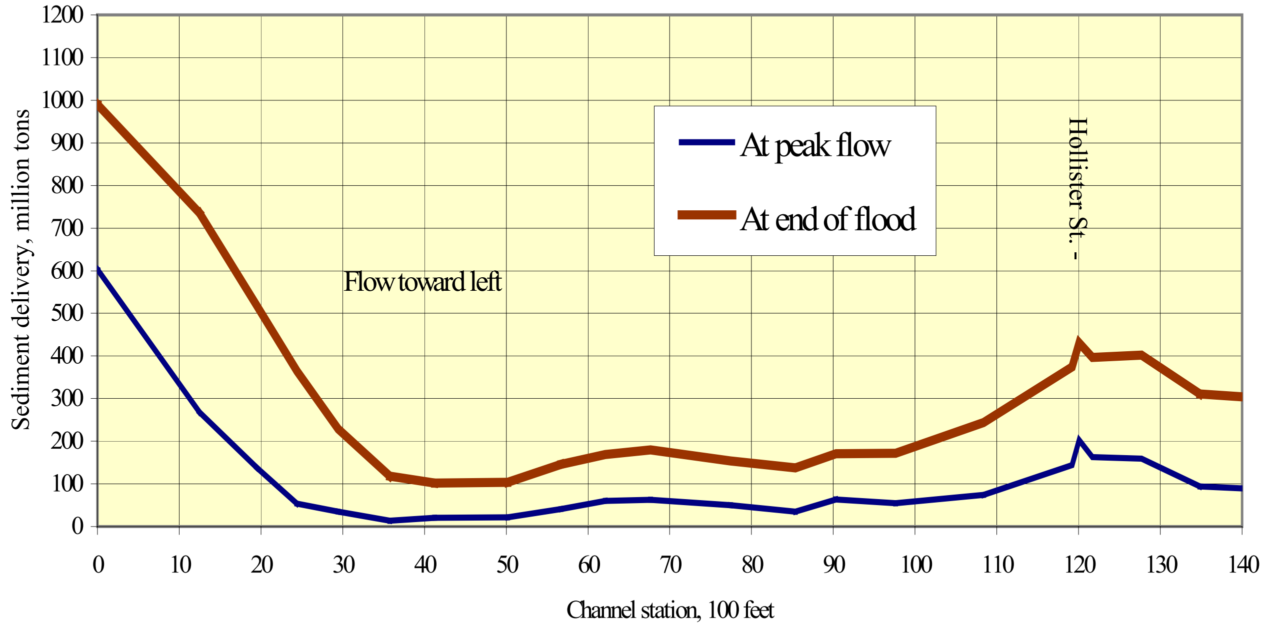


Figure 6-11. Spatial Variations of Sediment Delivery During 100-yr Flood for Existing Conditions

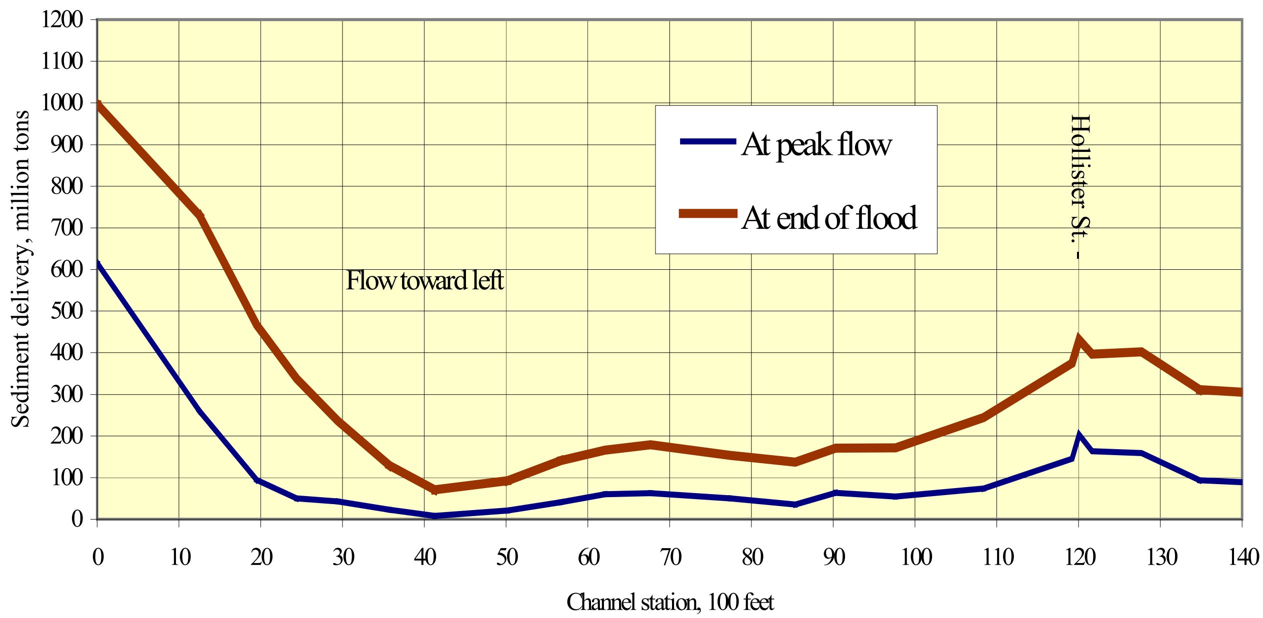


Figure 6-12. Spatial Variations of Sediment Delivery During 100-yr Flood for Proposed Conditions

6.8 Summary

The Tijuana Estuary lies at the confluence of a highly modified watershed with significantly altered stream flow, flood pattern and sediment balance within the system. The Friendship Marsh Restoration Project is designed to return the restored tidal wetlands to a more naturally functioning system in balance with both current river flood patterns and tidal processes. The restoration will lower elevations to improve tidal flushing and recharge, but this restored area will also become a natural sediment sink during river floods. To avoid sedimentation of the restored wetlands, a protective berm topped by a weir will be constructed between the main river channel and the restored marsh.

Modeling of flood patterns show that the berm will effectively protect the marsh from high water flows and all significant sediment deposition during floods. The weir acts as a valve, allowing the highest floodwaters to pass over the berm, consequently ensuring no increase in natural flood levels due to the berm. Modeling results also show that the main river channel and river mouth geometry are not significantly changed by the restoration or the berm. Scour and sedimentation patterns throughout the river length are largely unaffected, as are man-made structures such as bridges and roads.

6.9 Supplemental Hydraulic Analyses

As presented in Section 3.0 Restoration Goals, several projects are planned in the general vicinity of the Friendship Marsh restoration that could affect the project. Foremost among these is the 32-acre riparian restoration project proposed by the San Diego County Water Authority (SDCWA). That proposed restoration may include removal of a major berm that extends east-west along the south side of the Tijuana River. This berm is known locally as the AmSod Berm, as American Sod Farms or AmSod, a commercial grass turf company, formerly leased this area for turf production.

The removal of the AmSod berm could impact the design of the Friendship Marsh restoration. The protective berm and weir proposed for the Friendship Marsh restoration would connect with this existing berm. In order to assess the potential impact that removal of the AmSod berm would have on the Friendship Marsh, additional hydraulic analyses were conducted by the Rick Engineering Company. These are summarized below and presented in their entirety in Appendix F.

Hydraulic analyses were modeled using HEC-RAS Version 3.1.3, a 1-dimensional model created by the U.S. Army Corps of Engineers to determine water surface elevations (WSELs), velocities and other hydraulic characteristics for natural or engineered channels. While this model differs from the FLUVIAL-12 model used by Dr. Chang (2004), cross-section locations and topographic information were imported from the FLUVIAL-12 model into HEC-RAS, and Manning's n-values were based on the n-values modeled within the FLUVIAL-12 program.

Four scenarios were modeled:

- Alternative 1: (No-Action Alternative) Existing Berm Condition with Friendship Marsh Berm
- Alternative 2: (Preferred Alternative) Protected AmSod Condition with Friendship Marsh Berm
- Alternative 3: Alternative AmSod Condition with Friendship Marsh Berm
- Alternative 4: Existing Berms Removed Condition with Friendship Marsh Berm

All of the models were based on river geometry modeled from the FLUVIAL-12 analysis prepared by Dr. Chang (2004), with modifications to reflect each preliminary design alternative, and the proposed Friendship Marsh Berm configuration incorporated into all of the models. Both the 10-year 100-year flood analyses were conducted within the hydraulic models for reference; however, the emphasis of this report is the 100-year flood event. The preliminary WSELs and average velocities for both the 10-year and 100-year storm events can be found in Table 6.5 and Table 6.6, respectively.

Alternative 1: No-Action Alternative - *Existing Berm Condition with Friendship Marsh Berm*

The results of the HEC-RAS model for the No Action Alternative are depicted in Figure 6-13. This model is based on the existing condition geometry from the FLUVIAL-12 model including the existing berms within the Tijuana River Valley, the AmSod berm(s), and the proposed Friendship Marsh Berm. The area of ineffective flow is shaded blue. Locations of ineffective flow occur upstream and downstream of constrictions, and occur in areas impacted by the existence of earthen berms. In terms of effective and ineffective flow at the downstream end of the river, the results of this model compare well with the results of Dr. Chang's model of the Friendship Marsh Berm and AmSod berm presented previously. Thus, the 100-year WSELs computed with this model will serve as a baseline for comparison to determine the impact of the potential AmSod berm alternative configurations.

Alternative 2: (Preferred Alternative) - *Protected AmSod Condition with Friendship Marsh Berm*

The Preferred Alternative model is based on the assumption that all of the existing berms, with the exception of the AmSod berm(s), within the Tijuana River Valley have been removed. This model includes the proposed Friendship Marsh Berm. The HEC-RAS analyses include the associated ineffective flow areas for the AmSod and Friendship Marsh berms. The results of this model are depicted in Figure 6-14.

The removal of the existing berms within the Tijuana River Valley will increase the conveyance area, resulting in a general reduction of WSELs within the floodplain, when compared to the existing condition (no-action alternative). Measurable impacts to the floodplain begin at cross-

Table 6-5. Summary of 10-year WSELs and Velocities within the Tijuana River

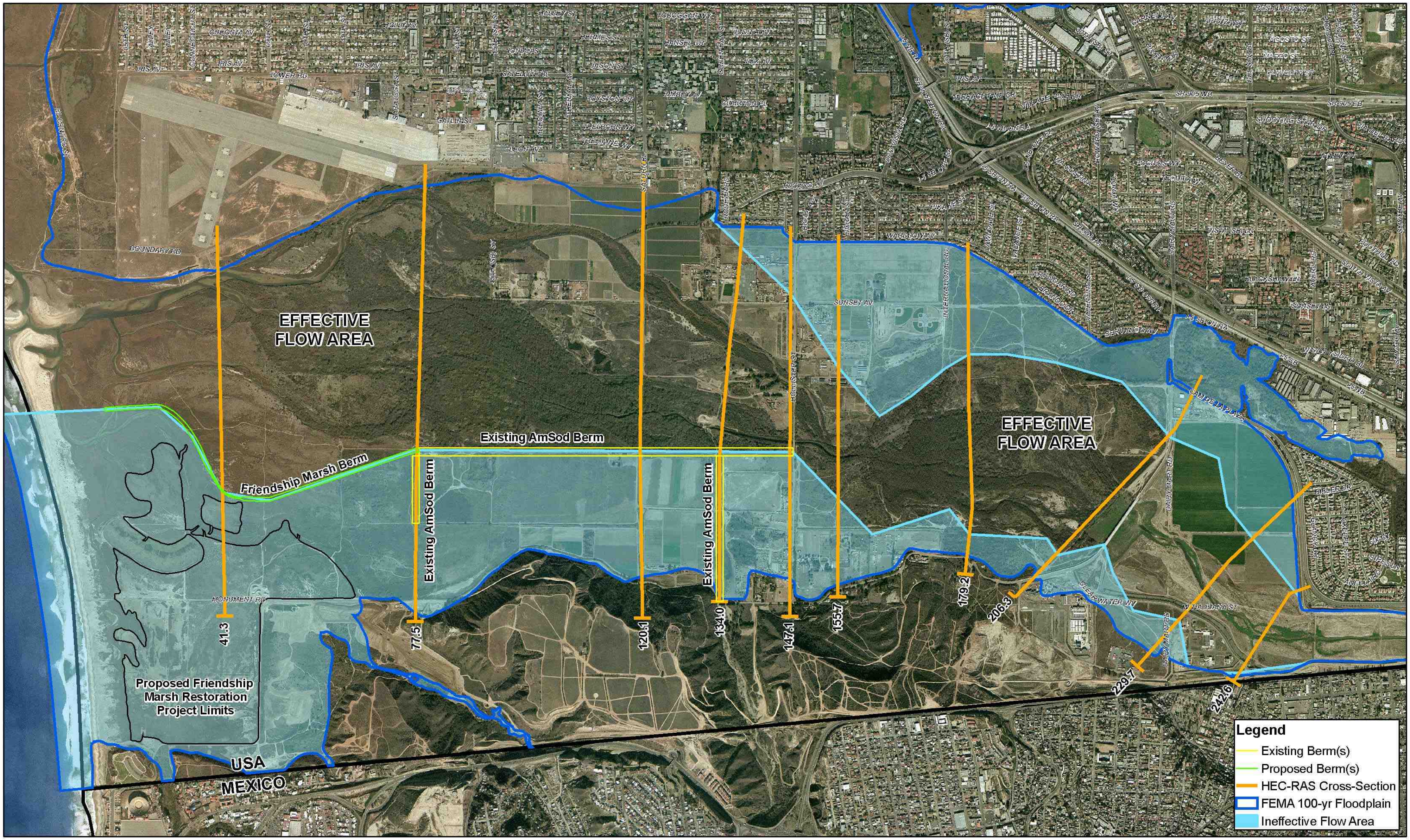
HEC-RAS Cross-Section (1)	Description	10-year Water Surface Elevation (ft)				Average Total Velocity (feet per second)			
		Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4
41.3		8.0	8.1	8.1	7.7	1.6	1.6	1.6	1.7
56.8		9.0	9.0	9.0	8.7	2.5	2.4	2.4	2.3
77.5	D/S end of AmSod berm	12.2	12.2	12.2	12.1	2.6	2.6	2.6	2.5
97.7		14.4	14.4	14.3	14.3	2.7	2.7	2.5	2.6
120.1	Saturn Boulevard	18.4	18.5	18.5	18.5	6.3	6.3	6.1	6.1
134.9	U/S end of AmSod berm	22.4	22.4	22.0	22.0	2.8	2.8	3.3	3.3
147.1	Hollister Street	23.7	23.7	23.3	23.3	4.8	4.7	4.4	4.4
155.7		24.3	23.9	23.7	23.7	7.6	9.0	9.6	9.6
179.2		26.7	26.5	26.5	26.5	1.7	1.8	1.8	1.8
206.3	Dairy Mart Road	30.5	30.3	30.3	30.3	2.3	1.6	1.6	1.6
229.7		38.6	38.6	38.6	38.6	4.0	4.0	4.0	4.0
242.6		40.5	40.5	40.5	40.5	3.5	3.5	3.5	3.5

D/S -Downstream
U/S -Upstream
(1) Not all cross-sections from the HEC-RAS models are included within the table above. The cross-sections within the table have been selected as key locations along the Tijuana River Valley. To view all of the cross-sections within the model, please refer to the comprehensive summary table and HEC-RAS workmap located in Appendices 2 through 6.

Table 6-6. Summary of 100-year WSELs and Velocities within the Tijuana River

HEC-RAS Cross-Section (1)	Description	100-year Water Surface Elevation (ft)				Average Total Velocity (feet per second)			
		Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4
41.3		14.7	14.6	14.6	14.5	2.1	2.0	2.0	2.0
56.8		14.9	14.9	14.9	14.7	2.3	2.3	2.3	1.9
77.5	D/S end of AmSod berm	16.0	16.0	16.0	15.4	3.2	3.2	3.2	2.6
97.7		18.2	18.2	17.9	17.5	3.5	3.5	2.9	3.2
120.1	Saturn Boulevard	21.5	21.5	21.0	21.0	5.7	5.7	6.1	6.1
134.9	U/S end of AmSod berm	25.2	25.1	24.6	24.6	5.0	4.7	4.8	4.8
147.1	Hollister Street	27.5	27.1	26.6	26.6	7.0	5.6	4.5	4.5
155.7		29.9	29.6	28.6	28.6	6.2	3.7	3.7	3.7
179.2		32.2	31.1	30.6	30.6	3.0	3.3	3.6	3.6
206.3	Dairy Mart Road	35.5	35.0	35.0	35.0	4.5	3.3	3.3	3.3
229.7		43.1	43.1	43.1	43.1	6.8	6.0	6.0	6.0
242.6		45.9	45.7	45.7	45.7	5.9	5.8	5.8	5.8

D/S -Downstream
U/S -Upstream
(1) Not all cross-sections from the HEC-RAS models are included within the table above. The cross-sections within the table have been selected as key locations along the Tijuana River Valley. To view all of the cross-sections within the model, please refer to the comprehensive summary table and HEC-RAS workmap located in Appendices 2 through 6.



RICK ENGINEERING COMPANY

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Date: 8/2/2007
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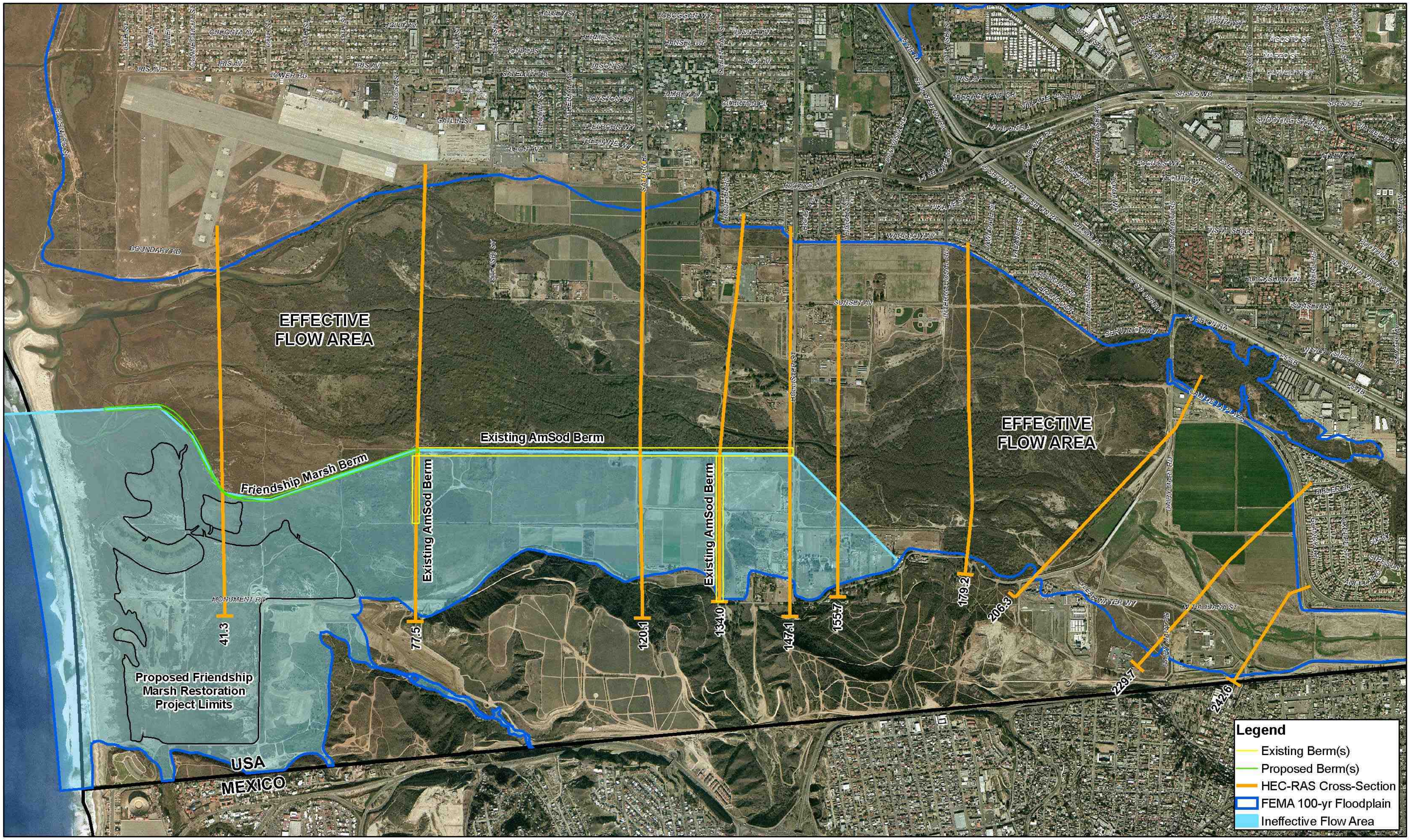
Alternative 1 : No Action Alternative
Existing Berm Condition with Friendship Marsh Berm

FIGURE 6-13



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Alternative 2 (Preferred Alternative)
Protected AmSod Condition with Friendship Marsh Berm

FIGURE 6-14

section 141.1, which is approximately 14,000 feet upstream from the mouth of the river. Between the downstream side of the AmSod property and the Dairy Mart Road crossing, impacts to the 100-year WSELs range from a decrease of approximately 0.2 feet at cross-section 141.1 to a decrease of approximately 1.2 feet during the 100-year storm at HEC-RAS cross-sections 168.9. More specific impacts to the 10-year and 100-year WSELs are summarized in Tables 6-5 and 6-6, respectively.

The increase in conveyance area reduces the average total velocity within the Tijuana River floodplain. The maximum decrease in average total velocity occurs at HEC-RAS cross-section 155.7, located upstream of Hollister Street, with a decrease of approximately 2.6 feet per second. More specific impacts to the 10-year and 100-year average total velocity are summarized in Table 6-5 and 6-6, respectively.

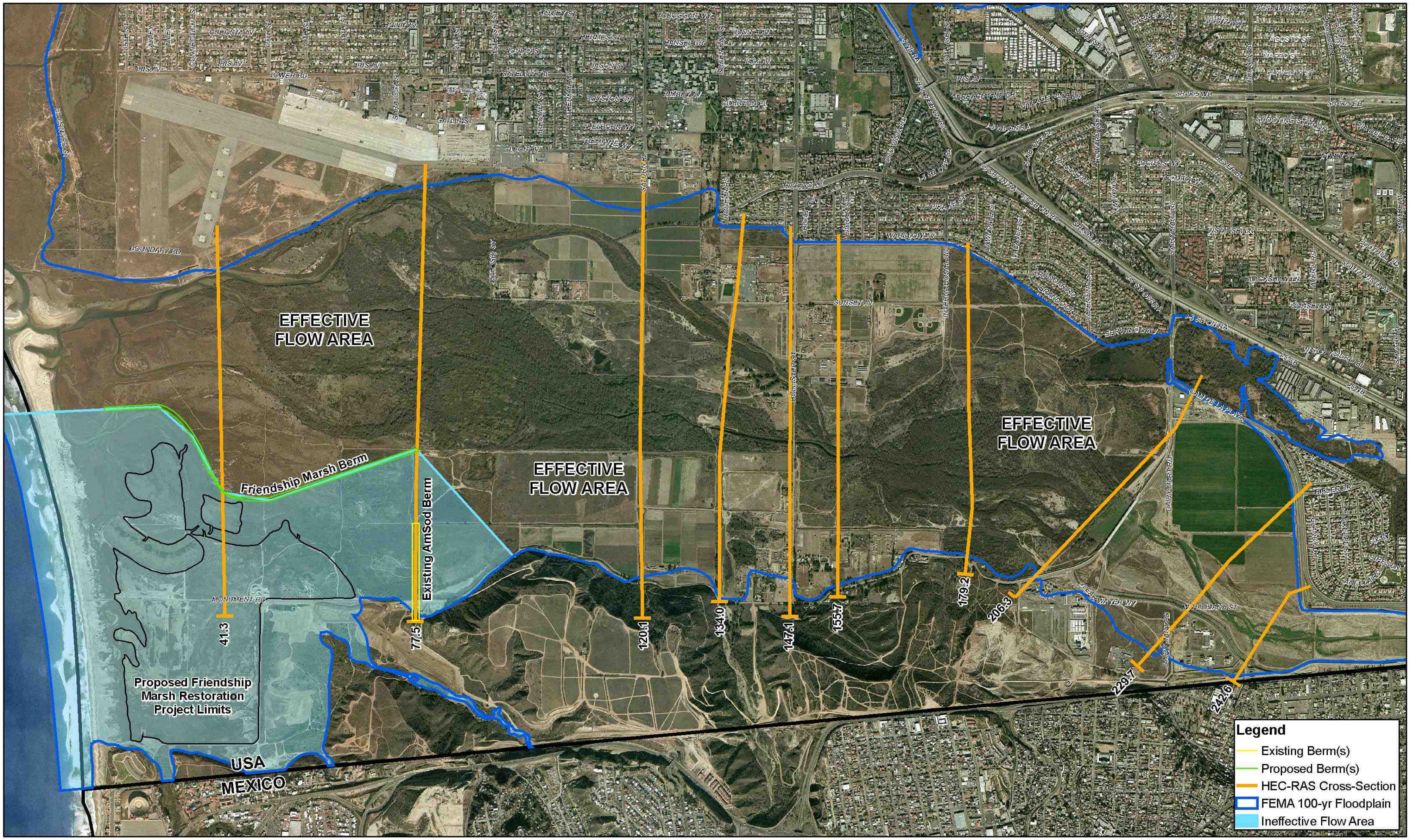
In the Alternative 2 (Protected AmSod Condition with Friendship Marsh Berm) model, the Friendship Marsh Restoration Project is located within an ineffective flow area created by the AmSod berm(s) and proposed Friendship Marsh Berm. As a result, the Friendship Marsh Restoration Project would be protected from inflows of sediment and debris transported by the Tijuana River.

Alternative 3: ***Alternative AmSod Condition with Friendship Marsh Berm***

The Alternative AmSod Condition with Friendship Marsh Berm model assumes that all of the existing berms within the Tijuana River Valley have been removed, including removal of a portion of the AmSod berm, and includes the proposed Friendship Marsh Berm. Currently, the downstream and upstream edge of the AmSod property is protected by existing earthen berms oriented in a north/south direction. The northern edge of the AmSod property is protected by an existing earthen berm oriented in a west/east direction. The portions of the AmSod berms would be removed for Alternative 3 are located at the upstream edge and northern edge of the AmSod property. The HEC-RAS analyses include the associated ineffective flow areas for the remaining western portion of the AmSod berm and the proposed Friendship Marsh Berm as depicted in Figure 6-15.

The removal of the northern and upstream AmSod berms will have negligible effects on WSELs downstream of the AmSod property, when compared to the existing condition (no-action alternative). Measurable impacts to the floodplain begin at cross-section 85.4, which is approximately 8,500 feet upstream from the mouth of the river. Between the downstream side of the AmSod property and the Dairy Mart Road crossing, impacts to the 100-year WSELs range from a decrease of approximately 0.1 feet at cross-section 85.4 to a decrease of approximately 1.8 feet at HEC-RAS cross-section 168.9. More specific impacts to the 10-year and 100-year WSELs are summarized in Tables 6-5 and 6-6.

The increase in conveyance area reduces the average total velocity within the floodplain. The maximum decrease in average total velocity occurs at HEC-RAS cross-section 147.8 and 155.7, with a decrease of approximately 2.5 feet per second. More specific impacts to the 10-year and 100 year average total velocity are summarized in Tables 6-5 and 6-6.



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Alternative 3
AmSod Berm Alternative Condition with Friendship Marsh Berm

FIGURE 6-15

In Alternative 3, the portion of the AmSod berm at the downstream side of the AmSod property would remain to aid in protecting the Friendship Marsh Restoration Project against sediment inflow and debris transported by the Tijuana River. The presence of this berm would maintain an ineffective flow area immediately upstream and would prevent the inflow of sediment and debris. The Friendship Marsh Berm proposed in the Friendship Marsh Restoration Project would connect to the downstream edge of the existing AmSod berm.

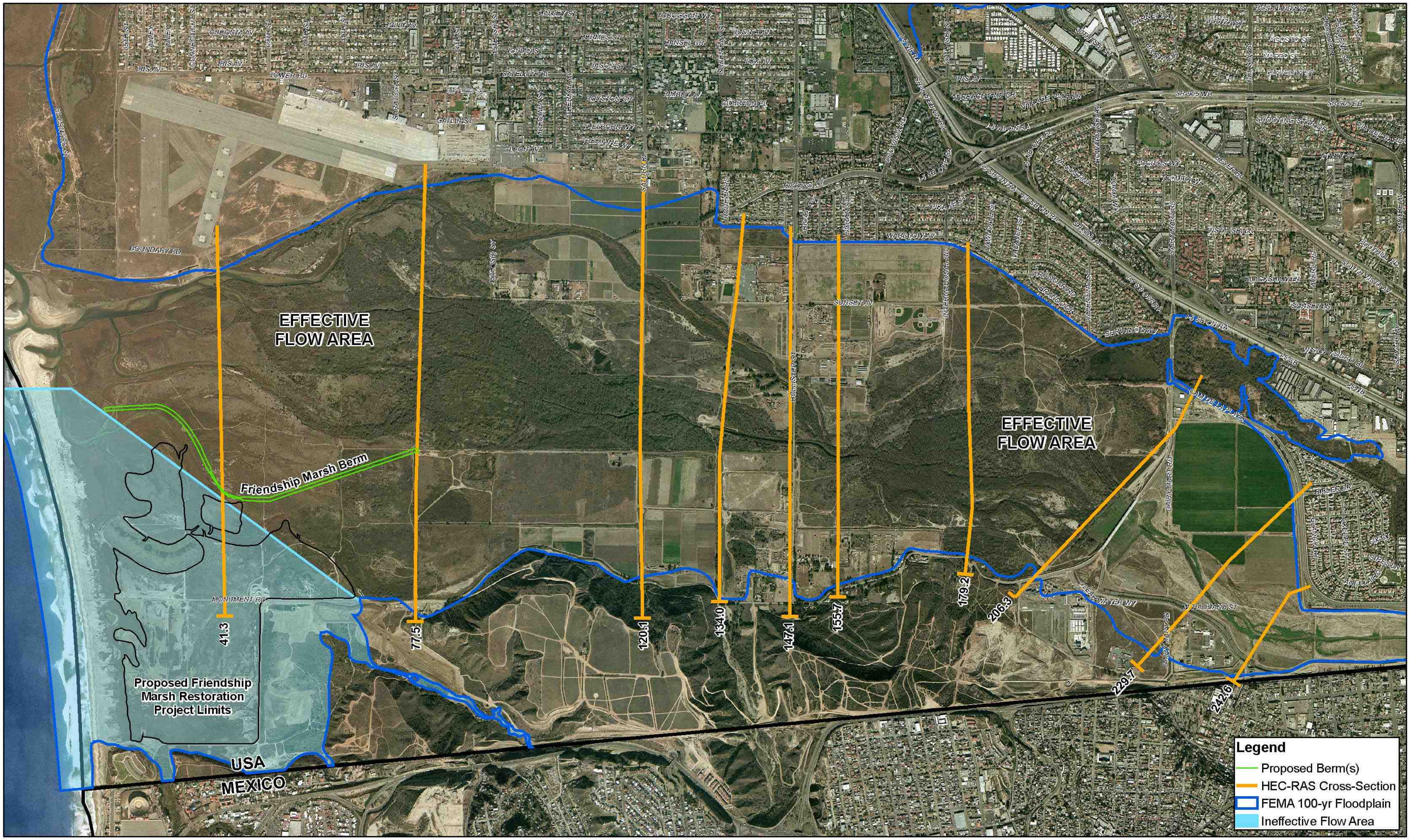
Alternative 4: ***Existing Berms Removed Condition with Friendship Marsh Berm***

Previous studies prepared by various stakeholders within the Tijuana River Valley have recommended that the existing berms within the valley, including the AmSod berm, be removed to restore the floodplain to a more natural drainage condition and reduce the flooding potential to adjacent property owners. Therefore, in the Alternative 4 model, the HEC-RAS cross-sections are extended and the ineffective flow areas, created by the existing berms modeled in Alternative 1, have been eliminated for a majority of the Tijuana River Valley. This scenario would allow floodwater to extend as far north and south as topography allows as illustrated in Figure 6-16.

This scenario has the largest flood-control benefit for the Tijuana River Valley. The removal of all the existing berms, including the AmSod berm(s), would increase the floodplain conveyance area resulting in the greatest reduction in WSELs within the floodplain when compared to Alternative 1. Measurable impacts to the floodplain begin at cross-section 35.8, which is approximately 3,500 feet upstream from the mouth of the river. Between HEC-RAS cross-section 35.8 and the Dairy Mart Road crossing, the impacts to the 100-year WSELs range from a decrease of approximately 0.1 feet at cross-section 35.8 to a decrease of approximately 1.8 feet at HEC-RAS cross-section 168.9. More specific impacts to the 10-year and 100-year WSELs are summarized in Tables 6-5 and 6-6.

The resulting increase in conveyance area would reduce the average velocity within the floodplain. The maximum decrease in the average total velocity occurs at HEC-RAS cross-section 147.8 and 155.7 with a decrease of approximately 2.5 feet per second. More specific impacts to the 10-year and 100-year average total velocity are summarized in Tables 6-5 and 6-6.

Aside from the flood control benefits, Alternative 4 has several distinct disadvantages. Complete removal of all of the AmSod berm(s)would allow floodwater from the Tijuana River to inundate all of the AmSod property and the effective flow areas of the floodplain limits would extend south to Monument Road. This would allow sediment-laden floodwater from the Tijuana River to flow directly into the Friendship Marsh Restoration area. In addition to this increased inundation, the natural constriction at the mouth of the Tijuana River would create an ineffective flow area within the restoration area. This could result in large quantities of sediment deposition in the northeastern portion of the Friendship Marsh, damaging or hindering habitat restoration efforts. Riparian habitat restoration could also become more difficult to establish within the AmSod property without the protection from sediment and debris inflow currently provided by the berms within the property limits.



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Alternative 4
Existing Berms Removed Condition with Friendship Marsh Berm

0 1,250 2,500 Feet

FIGURE 6-16

6.9.1 Anticipated Impacts of AmSod Berm Removal

The existing AmSod berm in its current configuration acts as a barrier, protecting the area proposed for the Friendship Marsh Restoration Project from damage due to high flood flows, sedimentation, and debris. In addition, the AmSod berm also provides a connection point for the proposed Friendship Marsh Berm that also functions as a protective barrier from debris and sediment generated by 10-year flood events.

Complete removal of the AmSod berm(s) could have the following anticipated effects:

- Elimination of the ineffective flow area(s) upstream and downstream of the AmSod property.
- Inundation of the AmSod property with storm flows conveying high levels of sediment and debris transported by the Tijuana River.
- Interference with future riparian habitat restoration efforts within areas subject to high sediment inflows.
- Increased frequency of storm flows within the Tijuana River Valley with potential flows southeast towards Monument Road and the Friendship Marsh Restoration Project.
- Potential deposition of large amounts of sediment and debris from the Tijuana River in the restoration area, hindering restoration efforts.

The AmSod berm in its current location and configuration in conjunction with the proposed Friendship Marsh Berm acts a physical barrier again sediment and debris inflow from the Tijuana River. With the removal of the Friendship Marsh Berm, an ineffective flow area could occur just south of the Friendship Marsh Berm because of the constriction at the mouth of the Tijuana River. Floodwater from the Tijuana River approaching this ineffective flow area would contain sediment from upstream. This sediment would be deposited as the floodwater velocities decrease in the transition from the effective to ineffective flow area.

If the AmSod berm is removed, the Friendship Marsh Berm may need to be realigned to recreate the physical barrier against sediment and debris inflow that is currently provided by the existing AmSod Berm. A possible realignment would leave the western half of the proposed berm in its current location, and would realign and extend its eastern half to connect with Monument Road located to the south. Any berm realignment would require further hydraulic analysis to quantify the impacts to the Tijuana River Floodplain.

6.9.2 Anticipated Impacts of Breaching the AmSod Berm

To meet the SDCWA goal of restoring the riparian habitat within the AmSod property while reducing the potential impacts to the Friendship Marsh Restoration Project, portions of the

AmSod berm could be breached as an alternative to its complete removal. Constructing engineered drainage structures through the AmSod berm(s), or removing specific portions of the berm(s), could allow floodwater to inundate the AmSod property in a controlled manner and would aid in restoring the riparian habitat within the property. Most of the AmSod berm would remain in its current location; thus maintaining the ineffective flow characteristics within the AmSod property. The remaining AmSod berm also would protect the Friendship Marsh Restoration Project, and any SDCWA habitat restoration efforts, from sediment and debris damage during storm flows in the Tijuana River Valley. The hydraulic impacts of breaching portions of the berm on the Tijuana River floodplain would be approximately the same as Alternative 2.

The location, configuration, and dimensions of the proposed breach(es) along the AmSod berm will require further consideration and additional engineering analysis, as well as consultation with a Geotechnical Engineer. However, based on the findings within this preliminary study, the breaches could be placed at two conceptual locations along the AmSod berm.

Single Breach

One option would create a breach at the downstream (western) end of the AmSod property, immediately upstream of the connection for the Friendship Marsh Berm and AmSod berm. At this location, the floodwater would encroach into the AmSod property and pond to a WSEL lower than the existing top of berm elevation. The 100-year WSEL in the Tijuana River at the downstream end of the AmSod property is approximately 15.8 feet, and the average elevation of the crest of the existing AmSod berm ranges from 16 feet at the downstream end to approximately 26 feet at the upstream end. At a 100-year WSEL of 16.0 feet, approximately 60% of the northwestern portion of the AmSod property would be inundated during the 100-year storm with this single breach location. At a 10-year WSEL of 12.2 feet, approximately 20% of the northwester portion of the AmSod property would be inundated during the 10-year storm with a breach at the western end of the AmSod berm.

Multiple Breaches

A second option would create two (or more) breaches within the AmSod berm. An inlet breach location could be constructed towards the upstream (eastern) end of the AmSod berm. The WSELs within the AmSod property will be approximately equivalent to the WSELs within the Tijuana River Valley floodplain at the location of the breach(es). As an example, if the breach were placed at HEC-RAS cross-section 120.1, the 100-year WSEL within the berms would be approximately 22.2 feet. That WSEL would be sufficient to inundate the property; however, it could result in floodwater overtopping the berm along the western and southern berms downstream. This could have potential negative impacts to the Friendship Marsh Restoration Project and may require further analysis. Additional breach(es) at the western end of the AmSod berm would also be required in this alternative to provide an outlet for the floodwaters back into the Tijuana River Valley.

6.10. Hydraulic Analysis of the Project Without the Proposed Berm and Weir

During project review, it was noted that the demarcation between the effective and ineffective flow as determined by the FLUVIAL 12 model occurred near the northern end of the proposed restoration. It appeared as though the proposed berm and weir would provide protection for only that small restored area to the northeast of the effective/ineffective flow boundary (Figure 6-17). Therefore it was decided that Rick Engineering Company (Rick) should conduct additional hydraulic analyses to illustrate the effects of sedimentation and scour on the preferred restoration site without the proposed berm and weir. The results of this analysis are presented below. The entire report prepared by Rick is included in Appendix G.

At Tijuana Estuary, the mouth of the estuary creates a constriction in the floodplain that forces the majority of the river's flood conveyance to the north. The FLUVIAL 12 model predicts a line or demarcation above which the flows are termed "effective" and below which they are termed "ineffective". The ineffective flow area may be defined as a region that is inundated during a flood but does not contribute to the overall downstream conveyance of water. Within this ineffective zone, the floodwaters will result in inundation; however, the velocity of the flows are diminished and theoretically approach zero in the downstream direction of flow. This does not imply that there is absolutely no movement of water as this zone would include eddies and other turbulence that do not contribute to the overall conveyance of the flood flows. The ineffective flow boundary is an approximate boundary predicted by the model that separates flows moving downstream (effective flows) from those that are not (ineffective flows).

Rick reviewed the hydraulic calculations prepared for the project to identify the flow velocities and shear forces occurring in the area demarcated as the ineffective flow area during a range of flood events. Based on the shear forces calculated by the model along the ineffective flow boundary, the Tijuana River has the force to transport sediment as large as 5 mm (small gravel) diameter. It should be noted that these calculations were based on a rigid-bed 1-dimensional hydraulic model that was used as an estimate of the river's sediment transport capacity only. The model does not calculate the volumes or characteristics of the sediment transported.

The sediment analysis conducted by AMEC Earth and Environmental (See Section 8.0 Substrate Characterization) has referenced to determine the shear forces of the river flows and sediment transport capabilities. Table 6.7 summarizes the grain size distributions along the ineffective flow boundary. The location of each sample location is presented in Figure 6-17. Based on the grain size data available for the AMEC report, the majority of the existing bed material will be subject to sediment transport. These data suggest that the channel bed will be highly mobile as flows approach the ineffective flow boundary. Once this sediment-laden water crosses into the ineffective flow area, it will begin to lose energy resulting in sediment deposition within the restored wetland.

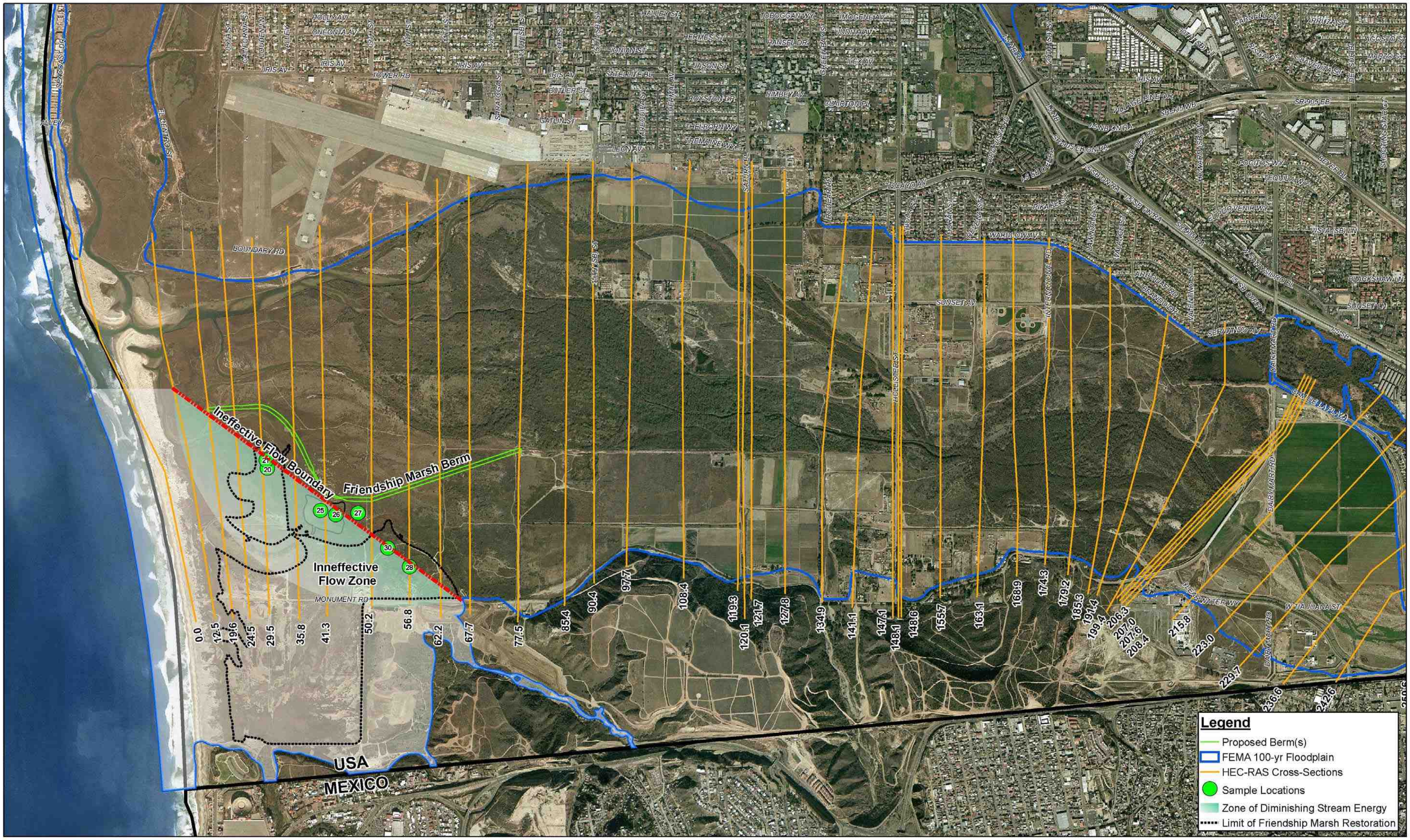

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FIGURE 6-17
Hydraulic Analysis of Project Without Proposed Berm and Weir

Table 6.7. Grain Size Characteristics of Channel Bed Adjacent to Ineffective Flow Boundary

Grain Size (mm)	Sample Location						
	20	21	25	26	27	28	30
>2	2.01%	0.10%	0.33%	2.69%	1.82%	0.03%	2.77%
1	9.36%	0.77%	0.59%	7.71%	4.24%	0.07%	0.92%
0.5	37.95%	8.59%	10.19%	30.25%	18.29%	0.27%	8.11%
0.25	34.80%	28.94%	49.99%	40.42%	39.35%	29.24%	53.14%
0.125	9.86%	41.90%	22.27%	14.30%	25.28%	43.65%	20.78%
0.075	2.30%	11.14%	6.56%	1.97%	4.27%	13.98%	5.47%
0.063	0.11%	1.03%	1.18%	0.23%	0.43%	1.05%	0.57%
0.031	0.00%	0.00%	1.48%	1.21%	0.00%	7.80%	4.70%
0.016	1.20%	1.26%	2.96%	0.00%	1.26%	0.00%	1.18%
0.008	0.00%	0.00%	0.00%	0.00%	0.00%	1.30%	1.18%
0.004	0.00%	2.51%	1.48%	0.00%	2.53%	0.00%	0.00%
0.002	0.00%	1.26%	0.00%	1.21%	1.26%	0.00%	0.00%
0.001	1.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
<0.001	1.20%	2.51%	2.96%	0.00%	1.26%	2.60%	1.18%

Source: AMEC Earth & Environmental Inc., 2005

The zone of sediment deposition is illustrated in Figure 6-17. The crescent-shaped area south and west of the ineffective flow boundary represents a zone of diminishing deposition until zero flow is predicted south of Monument Road and near the beach.

Based on this analysis, it is the opinion of Rick Engineering that the proposed berm and weir are necessary to prevent sediment transport and deposition in the restored wetland. It should be noted that the existing Model Marsh is currently vulnerable to sedimentation from the Tijuana River, as well as sedimentation from Goat Canyon and, potentially, Yogurt Canyon.

7.0 BIOLOGICAL RESOURCES

The biological resources of the Tijuana Estuary have been the focus of numerous studies culminating in a summary of the aquatic and terrestrial habitats presented in *The Ecology of Tijuana Estuary: An Estuarine Profile* (Zedler and Nordby 1986) and its update *The Ecology of Tijuana Estuary: A National Estuarine Research Reserve* (Zedler et al. 1992). Much of the data presented in these publications was collected from studies in the northern arm of the estuary. The current project area, located in the southern arm of the estuary, has received less attention, primarily a result of its degraded state. During the initial phases of this project, it was determined that updated surveys of vegetation and selected wildlife species would be required in order to adequately address potential project benefits and impacts. Accordingly, focused surveys of flora and fauna were conducted in the southern arm in 2004 and 2005. The 2004 survey area encompassed an area of approximately 600 acres while surveys in 2005 focused on the approximately 260-acre Preferred Project Area. The results of these surveys, as well as those conducted in support of the Tijuana Estuary Tidal Restoration Program EIR/EIS (Entrix et al. 1991), are summarized below. Detailed information on biological resources potentially affected by the current study is presented in Appendix C.

7.1 Vegetation Communities

The composition of vegetation communities in the Tijuana River Valley has been influenced by numerous factors, including freshwater input, sedimentation, and disturbance from border patrol, military and agricultural uses. Historically, the project area was tidally influenced and received freshwater primarily during the rainy season in late winter and spring. Recently, however, wastewater inflows from the City of Tijuana, located immediately south of the project area, have resulted in increased freshwater influence over a greater proportion of the area. Although much has been done to reduce the volume of freshwater entering the estuary via sewage flows, this physical factor remains a negative influence in the project area.

The project area also has been negatively affected by increased residential development in Tijuana that has resulted in erosion, particularly of unstable bluffs and, consequently, increased sediment deposition in the river valley. Over time, this sedimentation has resulted in raising the elevation of the marsh plain in the project area. Higher elevations combined with freshwater flows have facilitated colonization by exotic plant species in many areas that once supported only salt marsh plant species.

In addition to changes in the physical environment over time, vegetation in the project area has been directly impacted by border patrol, military and agricultural activities that have resulted in damage to native vegetation communities and the introduction, and increased proportion, of non-native species. A summary of recent changes in the project area is presented in Section 2.4 History of Disturbance.

Although it has been subject to much disturbance in the recent past, Tijuana Estuary supports a diversity of native vegetation communities and wildlife. Vegetation observed in the project area includes saltwater and freshwater marsh communities as well as those typical of more xeric habitats. Many of these communities have been greatly reduced in southern California. As a result, many of the plant and wildlife species that rely on them for survival are now threatened with extinction. Coastal salt marsh associated with Tijuana Estuary is considered to be particularly valuable as approximately 91 percent of coastal wetlands in the state of California have been lost to development (California Department of Fish and Game, 2001).

Wherever possible, vegetation communities of the project area were described according to the nomenclature of Holland (1986). However, due to the pervasiveness of introduced species and uncommon plant assemblages observed on-site, additional vegetation community categories that best described these areas were created. A total of 21 vegetation communities were observed within the survey area. In addition, unvegetated habitats, such as disturbed salt panne habitat, were observed. A list of the vegetation communities recorded during project surveys is presented below.

- Southern foredunes
- Southern coastal salt marsh
- Disturbed southern coastal salt marsh
- Disturbed salt panne
- Mule-fat scrub
- Disturbed mule-fat scrub
- Coastal brackish marsh
- Disturbed coastal brackish marsh
- Southern willow scrub
- Disturbed southern willow scrub
- Coastal freshwater marsh
- Disturbed freshwater marsh
- Maritime succulent scrub
- Disturbed maritime succulent scrub
- Transitional habitat
- Saltbush scrub
- Salt marsh fleabane scrub
- Non-native grassland
- Tamarisk scrub
- Disturbed upland habitat
- Ruderal
- Ornamental

The 2005 distribution of the vegetation communities observed in the extended project area is illustrated in Figure 7-1. This 2005 condition is compared to the 2004 vegetation communities that existed prior to sediment deposition in January 2005 (Figure 7-2). A comparison of the two vegetation maps demonstrates the damage resulting from this event. The greatest impact to Tijuana Estuary was observed within the area west of Monument Road and south of the beach access horse trail. Post-storm effects observed included the conversion of disturbed salt marsh habitat to disturbed mule-fat scrub and the conversion of disturbed southern coastal salt marsh and salt panne to disturbed brackish marsh.

FIGURE 7-1 Vegetation Communities of the Project Survey Area, 2005

SF/Southern Foredunes
SM/Southern Coastal Salt Marsh
DSM/Disturbed Southern Coastal Salt Marsh
SP/Salt Panne
DMFS/Disturbed Mule-fat Scrub
SWS/Southern Willow Scrub
DSWS/Disturbed Southern Willow Scrub
FWM/Coastal Freshwater Marsh
DFWM/Disturbed Coastal Freshwater Marsh
TH/Transitional Habitat
SBS/Saltbush Scrub
NNG/Non Native Grassland
TAM/Tamarisk Scrub
DUPLAND/Disturbed Upland Habitat
ORN/Ornamental
DEV/Developed
DIST/Disturbed
SMFS/ Salt Marsh Fleabane Scrub
BEACH/Beach
BM/Coastal Brackish Marsh
MSS/Maritime Succulent Scrub
DCSS/Diegan Coastal Sage Scrub
DDCSS/Disturbed Diegan Coastal Sage Scrub
DSF/Disturbed Southern Foredunes
DSM/DUPL/Disturbed Southern Coastal Salt Marsh/Disturbed Upland Habitat
DSM/SP/Disturbed Salt Marsh/Salt Panne
MFS/Multi-fat Scrub
RUD/Ruderal
TC/Tidal Channel

RICK ENGINEERING COMPANY

TIJUANA ESTUARY
2004

1 inch equals 800 feet
0 400 800 Feet

FIGURE 7-2 **Vegetation Communities of the Project Survey Area, 2004**

Within each habitat type, the proportion of native and exotic plant species varies greatly, from relatively undisturbed native communities to habitats that support monotypic stands of exotic species. However, nearly all of the habitats described below are either dominated by or support some non-native species, a situation compounded by fresh water inflows and sediment deposition. A complete list of plant species observed in the project area is presented in Appendix C.

<u>Southern Foredune</u>. Southern foredune is a sparsely vegetated community that is dominated by suffrutescent plants (Holland 1986). Plant species that area characteristic of this habitat include red sand-verbena (*Abronia maritima*), beach sand-verbena (*Abronia umbulata*), and beach-bur (*Ambrosia chamissonis*). Within the project area, this vegetation community was dominated by of beach-bur, beach sand-verbena, beach evening-primrose (*Camissonia cheiranthifolia* ssp. *suffruticosa*) and Hottentot fig (*Carpobrotus edulis*).

<u>Southern Coastal Salt Marsh.</u> Pristine coastal salt marsh can be described as a highly productive habitat, dominated by herbaceous and suffrutescent, salt-tolerant hydrophytes that form moderate to dense cover and grow up to 1 meter tall (Holland 1986). This vegetation community is usually segregated by elevation with California cordgrass (*Spartina foliosa*) occurring at lower elevations, pickleweed (*Salicornia virginica*) and other halophytic succulents occurring at mid-littoral elevations, and an assemblage of species occurring at the upper littoral elevations. This habitat supports an intricate food web rich in both invertebrate and vertebrate species. In addition, this vegetation community provides habitat for the federally listed endangered light-footed clapper rail (*Rallus longirostris levipes*) and salt marsh bird's beak (*Cordylanthus maritimus* ssp. *maritimus*), and stated-listed endangered Belding's savannah sparrow (*Passerculus sandwichensis beldingi*). The majority of the salt marsh vegetation that occurs in the project area is disturbed by sediment deposition and invasive non-native species.

Plant species typical of coastal salt marsh include pickleweed, alkali heath (*Frankenia salina*), fleshy jaumea (*Jaumea carnosa*), western marsh rosemary (*Limonium californicum*), and California cordgrass (Holland 1986). Most species are active during the summer months and dormant during the winter months. A total of 16 plant species were observed in the project area, including cordgrass, pickleweed, jaumea, glasswort (*Salicornia subterminalis*), shoregrass (*Monathochloe littoralis*) and saltgrass (*Distichlis spicata*; Appendix C).

Southern coastal salt marsh occurs throughout the project area. Historically, this vegetation community extended over a greater area than it does today and was much more pristine. Today, much of the coastal salt marsh habitat is a remnant of the days before sedimentation impacted the area. The majority of this remnant habitat is non-tidal, persisting on rainfall and run-off and has been invaded by weedy, non-native species. As such, the function of this typically productive habitat has been severely compromised.

<u>Salt panne habitat.</u> Salt panne habitat can be described as a basin or small depression that traps marine waters during the highest spring tides and rainfall during wet periods. During the summer months, the water in these basins rapidly evaporates, resulting in hypersaline soils devoid of vegetation. During the winter, the pannes hold water and support algae and aquatic insects (Zedler et al. 1992). Typically, salt pannes hold water only for a short period each year.

Consequently, the productivity and complexity of the communities associated with this habitat are not well understood (Zedler et al. 1992). Salt panne habitat in the project area once supported nesting and foraging shorebirds, most notably black-necked stilts (*Himantopus mexicanus mexicanus*) and American avocet (*Recurvirostra americana*). However, that function has diminished as a direct result of sediment deposition. Today, the former salt panne habitat is elevated above tidal influence and no longer impounds seasonal rainfall. The area has been invaded by primarily non-native grasses and is gradually succeeding to disturbed upland habitat.

<u>Mule-fat scrub.</u> Mule-fat scrub is a depauperate, tall herbaceous riparian scrub strongly dominated by mule-fat (*Baccharis salicifolia*; Holland 1986). This early seral community is maintained by frequent flooding. Much of the mule-fat scrub in the project area is considered disturbed due to the high proportion of exotic species that occur among mule-fat. These include tree tobacco (*Nicotiana glauca*), castor bean (*Ricinus communis*), cocklebur, and nutsedge (*Cyperus* sp.). Although this vegetation community occurs naturally within the project area, recent sedimentation and wastewater flows have greatly increased its range. The approximately 15-acre area of former disturbed salt marsh/salt panne that was covered with sediment in January 2005 has become colonized by a combination of mule-fat and exotic species (Figure 7-1).

<u>Coastal Brackish Marsh.</u> Coastal brackish marsh is a vegetation community dominated by perennial, emergent herbaceous monocots approximately 2 meters in height (Holland 1986). Vegetative ground cover is often complete and dense. This vegetation community is similar to coastal salt marsh and to freshwater marsh with some plants characteristic of each.

Historically, much of the area currently designated as brackish marsh was coastal salt marsh. However, renegade sewage flows from Mexico and floods from Goat Canyon and Yogurt Canyon have provided an input of freshwater that has created brackish conditions in these areas, allowing for the colonization of freshwater marsh plants. Although this vegetation community provides habitat for wildlife species, conversion of salt marsh habitat to brackish marsh habitat has resulted in a loss of this regionally rare habitat type. Furthermore, with continued pulses of stormwater entering the project area from Mexico, invasive weed species have become established in this habitat, as well as in coastal salt marsh and coastal freshwater marsh habitat. Plant species observed on the project area included pickleweed (*Salicornia virginica*), glasswort (*S. subterminalis*), Olney's bulrush (*Scirpus maritimus*), narrow-leaved cattail (*Typha angustifolia*), European cocklebur (*Xanthium strumarium*), curly dock (*Rumex crispex*), annual beard grass (*Polypogon monspeliensis*), and yerba manza (*Anemopsis californica*).

<u>Southern Willow Scrub.</u> Southern willow scrub is described by Holland (1986) as a dense, broad-leafed, winter-deciduous riparian thicket dominated by several willow species (*Salix* spp.), with scattered emergent western cottonwood (*Populus fremontii*) and western sycamore (*Platanus racemosa*). Historically, southern willow scrub was confined to freshwater riparian areas within the project area. This vegetation community, however, has also benefited from stormwater and sewage inflows and currently occurs over a greater area. Southern willow scrub is no longer confined to the river channels, but occurs where sewage and stormwater flows occur. Other species typically observed in this vegetation community include arrow weed (*Pluchea sericea*) and great marsh evening-primrose (*Oenothera elata* ssp. *hookeri*). In the project area, southern willow scrub supports exotic plant species and is thus described as

disturbed. Plant species observed on the project area included arroyo willow (*Salix lasiolepis*), red willow (*Salix laevigata*), mule-fat (*Baccharis salicifolia*), salt marsh fleabane (*Pluchea odorata*), Brazilian pepper tree (*Schinus molle*), and eucalyptus (*Eucalyptus* sp.).

<u>Coastal Freshwater Marsh.</u> Coastal freshwater marsh is dominated by perennial, emergent monocots 4 to 5 meters tall, often forming completely closed canopies (Holland 1986). Plant species characteristic of this community include willow sedge (*Carex lanuginosa*), yellow nutsedge (*Cyperus esculentus*), spike sedges (*Eleocharis* spp.), cattails (*Typha* spp.), and viscid bulrush (*Scirpus acutus*). Like southern willow scrub, freshwater marsh was historically confined to freshwater riparian areas within the project area. This vegetation community, however, has also been affected by sewage inflows is no longer confined to the river channels but occurs where the sewage flows. In the project area, coastal freshwater marsh is dominated by narrow-leaved cattail (*Typha angustifolia*). In addition to extending the range of this vegetation community within the project area, sewage flows and other disturbances have resulted in the colonization of exotic plant species. As a result, coastal freshwater marsh can be currently described as disturbed. Exotic plant species observed in this habitat type include European cocklebur and curly dock.

<u>Maritime Succulent Scrub.</u> Maritime succulent scrub is a low, open scrub that occurs on thin rocky or sandy soils, often on steep slopes of coastal headlands and bluffs. This vegetation community is dominated by drought deciduous, subligneous, malacophyllous shrubs and has a rich admixture of stem and leaf succulents. Plant species that are characteristic of this vegetation community include Shaw's agave (*Agave shawii*), coastal sagebrush (*Artemisia californica*), and coast barrel cactus (*Ferocactus viridescens*). Plant species observed in this vegetation community included coastal sagebrush, shaw's agave, lemonadeberry (*Rhus integrifolia*), snake cholla (*Cylindropuntia californica* var. *californica*), coast cholla (*Cylindropuntia prolifera*), prickly pear (*Opuntia littoralis*), and bladderpod (*Isomeris arborea*).

The strong presence of exotic plant species and low diversity of native species are the characteristics that distinguish disturbed maritime succulent scrub from maritime succulent scrub.

<u>Transitional Habitat.</u> Although not a Holland category, the term transitional habitat has been used by numerous wetland biologists to described areas that support high elevation coastal salt marsh elements and upland plant species. Typically, this habitat type occurs as a narrow band where upland habitats and wetland habitats overlap (Zedler et. al. 1992).

Within the project area, transitional habitat occurs as a large area that once supported salt marsh habitat. As a result of sedimentation and agricultural practices, native shrub species have colonized these areas. Plant species observed in this habitat type included glasswort, California desert thorn (*Lycium californicum*), spreading goldenbush (*Isocoma menziesii* var. *menziesii*), bush seepweed (*Sueda moquinii*), alkali-heath (*Frankenia palmeri*), crown daisy (*Chrysanthemum coronarium*), five-hook bassia (*Bassia hyssopifolia*), and black mustard (*Brassica nigra*).

Salt marsh fleabane scrub. Salt marsh fleabane scrub describes areas that support monotypic stands salt marsh fleabane (*Pluchea odorata*). No other plant species were observed within this habitat type.

Non-native grassland. Non-native grassland is described as a dense to sparse cover of annual grasses with flowering culms 0.2-0.5 meters high. Germination occurs with the onset of the late fall rains; growth, flowering, and seed-set occur from winter through spring (Holland 1986). In the project area, non-native grassland is used to describe areas that once supported high elevation salt marsh habitat that, as a result of sedimentation and freshwater flows, are now dominated by non-native grasses. Sparsely distributed salt marsh elements, such as glasswort, were also observed; however, non-native grasses were the dominant species. Plant species observed in this vegetation community included ripgut grass (*Bromus diandrus*), soft chess (*Bromus hordeaceus*), foxtail chess (*Bromus madritensis* ssp. *rubens*) and scattered glasswort.

Tamarisk scrub. Tamarisk scrub describes areas that are dominated by salt cedar (*Tamarix* sp.). No other plant species were observed in tamarisk scrub habitat.

Disturbed upland habitat. Disturbed upland habitat describes areas that are recovering from agricultural practices, fire or other disturbances. These areas are dominated by colonizing native shrub species including spreading goldenbush, broom baccharis (*Baccharis sarothroides*), and spiny aster (*Aster spinosus*) often forming dense monotypic stands.

Saltbush scrub. Saltbush scrub describes area dominated by four-winged saltbush (*Atriplex canescens* ssp. *canescens*). It appears that this area may have been cleared in the past and that saltbush colonized the disturbed area.

Ruderal. Although not a Holland category, ruderal habitat best describes areas that have been heavily disturbed and, consequently, are dominated by weedy, exotic plant species. Areas once used for agricultural purposes support ruderal habitat. In addition, areas immediately adjacent to unofficial roads support ruderal habitat. Plant species observed in these areas include soft chess (*Bromus hordeaceus*), dock (*Rumex* sp.), crystalline iceplant (*Mesembryanthemum crystallinum*), wild radish (*Raphanus sativus*), crown daisy, tree tobacco, and star thistle (*Centaurea* sp.).

Ornamental. Ornamental describes landscaped areas that are irrigated and maintained by California State Parks.

Disturbed. The term disturbed is used to describe areas that have been subject to continual disturbance and as a result support sparsely distributed vegetation or are devoid of vegetation. Existing dirt roads and dirt paths are considered disturbed areas.

Developed. The term developed is used to described areas that support permanent structures, such as Monument Road and associated parking areas.

7.2 Wildlife

Faunal resources of the project area were historically both diverse and abundant. However, years of habitat degradation have had a negative effect, as documented in this section.

Numerous surveys have been conducted for aquatic and terrestrial wildlife species in the project vicinity; however, few have focused on the south arm of the estuary. Focused surveys of the south arm were conducted in support of the Tijuana Estuary Tidal Restoration Program EIR/EIS (Entrix et al. 1991). A summary of studies conducted for Tijuana Estuary Tidal Restoration Program is presented in Appendix C. Additional focused surveys of selected wildlife species were conducted in support of this feasibility and design study. The results of these surveys are summarized below.

7.2.1 Mammals

The presence of mammal species in the project area was documented during small mammal focused surveys conducted by Taylor and Tizler (Entrix et. al. 1991), and USFWS (1998). In addition, because many mammal species prey on endangered bird species, the presence of predatory mammals in the estuary has been the focus of the U.S. Department of Agriculture (USDA) Predator Management Program.

A focused survey of the mammals in the southern arm of the estuary was conducted by Taylor and Tizler in support of the 1991 tidal restoration program (Entrix et al. 1991). A total of 16 species from 4 orders and 8 families were captured during the trapping program for small mammals. These included Virginia opossum (*Didelphis virginianus*), California jackrabbit (*Lepus californicus*), desert cottontail (*Sylvilagus audubonii*), California ground squirrel (*Spermophilus beecheyi*), agile kangaroo rat (*Dipodomys agilis*), San Diego pocket mouse (*Chaetodipus fallax fallax*), deer mouse (*Peromyscus maniculatus*), cactus mouse (*Peromyscus eremicus*), brush mouse (*Peromyscus boyli*), dusky-footed woodrat (*Neotoma fuscipes*), western harvest mouse (*Reithrodontomys raviventris*), California vole (*Microtus californicus*), house mouse (*Mus musculus*), coyote (*Canis latrans*), striped skunk (*Mephitis mephitis*) and long-tailed weasel (*Mustela frenata*).

The type locality of the federally listed endangered Pacific pocket mouse (*Perognathus longimembris pacificus*) occurs near the project area on Spooner's Mesa and near the mouth of the Tijuana River (Montgomery 1995). Protocol surveys for this species were conducted in the project area by the USFWS (USFWS 1998). Pacific pocket mouse was not detected during these surveys. Rodent species captured during these surveys included northwestern San Diego pocket mouse, deer mouse, cactus mouse, brush mouse, harvest mouse, house mouse, agile kangaroo rat, dusky footed woodrat, and black rat (*Rattus rattus*).

The Predator Management Report for the Tijuana River National Estuarine Research Reserve produced by the USDA (2000) reported the following additional mammalian species; gray fox (*Urocyon cinereoargenteus*), feral cats (*Felis catus*), feral dog (*Canis familiaris*), and Norway rat (*Ratus norvegicus*). It should be noted that bobcat (*Lynx rufus*) has been observed in the project vicinity by Tierra as well as by California State Parks personnel. A list of all mammal species observed in the Tijuana Estuary is presented in Appendix C.

The presence of feral cats and dogs in the project vicinity has had a negative effect on native fauna. Feral cats are known to hunt reptiles, small mammals, and bird species. Predation by cats of light-footed clapper rail chicks and California least tern eggs and chicks has been documented by Predator Management. Although efforts to remove these species from the area continue year round, feral cats and dogs remain a problem.

7.2.2 Birds

The avifauna of Tijuana Estuary is diverse, exhibiting temporal and spatial variation in their abundance, distribution and activity (Kus and Ashfield 1989). More than 374 bird species have been documented in the Tijuana River Valley. This diversity in bird species can be attributed to the availability of a variety of habitats, including salt marsh, brackish marsh, intertidal mudflats, coastal scrub, dunes and riparian habitats. Ruderal areas that are of lower biological value than native communities also provide foraging grounds for many species of raptor.

The estuary is an important stop along the Pacific Flyway, a migratory route used by birds traveling between breeding sites in Arctic and sub-Arctic regions and southern wintering sites. Along this flyway, the Tijuana Estuary serves as a foraging and resting area. Although many birds continue to travel south during the late summer and fall months, many shorebird, water fowl, passerines, and raptor species winter at Tijuana Estuary.

During the summer months, many bird species nest at Tijuana Estuary. Although predator management is conducted for the benefit of endangered bird species, such as the light-footed clapper rail (*Rallus longirostris levipes*), California least tern (*Sterna antillarum browni*), and western snowy plover (*Charadrius alexandrinus nivosus*), many other nesting bird species also benefit from this practice. In addition to trapping predator species, the parasitic brown-headed cowbird (*Molothrus ater*), is also trapped and removed. The brown-headed cowbird has been known to parasitize the nests of many bird species, including the endangered least Bell's vireo (*Vireo bellii pusillus*), common yellow throat (*Geothlypis trichas*), yellow warbler (*Dendroica petechia bresteri*), and warbling vireo (*Vireo gilvus*).

The southern arm of Tijuana Estuary has recently been the focus of wildlife surveys conducted in support of several habitat management projects, including the Goat Canyon Enhancement Project. This project involved the construction of a series of sediment detention basins immediately east of the proposed project area. In support of the Goat Canyon Enhancement Project, new data was collected recently on the distribution and abundance of bird species adjacent to the project area. In addition, two focused surveys for the state endangered Belding's savannah sparrow (*Passerculus sandwichensis beldingi*) were conducted in support of this feasibility and design study. The results from those surveys are presented in Section 7.3 Sensitive Species.

Five federally listed and one state-listed threatened and/or endangered species occur in or immediately adjacent the project area. These include the federally and state-listed endangered

California least tern, light-footed clapper rail, California brown pelican, and least Bell's vireo; the federally listed threatened western snowy plover; and, the state-listed endangered Belding's savannah sparrow. In addition, sensitive bird species afforded the Federal Species of Concern and/or California Special Concern status occur in the project area. These include, gull-billed tern (*Sterna nilotica*), burrowing owl (*Athene cunicularia*), and California horned lark (*Eremophila alpestris actia*). The status of each of these species and the potential impacts from restoring the southern arm of the estuary are presented in Section 7.3 Sensitive Species.

7.2.3 Reptiles and Amphibians

Focused surveys for reptiles have not been conducted within the project area. However, surveys in the vicinity of the project area were conducted by the U.S. Geological Survey between 1997 and 1999. The surveys were conducted year-round and sampled three habitat types: coastal dune, mesa/slope, and marsh/upland habitat. Sampling of each of the three sample areas was conducted using a series of pit-fall drift-fence arrays. Surveys were conducted at 15 arrays each year. The results of trapping by arrays located in mesa top/slope habitat are not included in this discussion, as this habitat does not occur in the project area. Several reptile species were observed during these surveys, including coast horned lizard (*Phrynosoma coronatum*), California king snake (*Lampropeltis getula*), and silvery legless lizard (*Anniella pulchra*). Amphibian species observed during these surveys included pacific slender salamander (*Batrachoseps pacificus*), California tree frog (*Pseudacris* (*Hyla*) *cadaverina*), Pacific chorus frog (*Pseudacris* (*Hyla*) *regilla*) and western spadefoot toad (*Scaphiopus hammondii*). Sensitive reptile species observed within the project area include Federal Species of Concern and California Special Concern Species silvery legless lizard, coast horned lizard, and California Special Concern Species Coronado skink (*Eumeces skittonianus interparietalis*). The status of each of these species and the potential impacts from restoring the southern arm of the estuary are presented in Section 7.3. Sensitive Species. A list of species documented by the USGS as occurring in upper salt marsh and coastal dune habitats is presented in Appendix C.

7.2.4 Fish

Fish are an essential part of the wetland food chain due to their role in nutrient cycling and because, as prey items, they have the potential to transfer energy from a marine environment to a terrestrial environment. This is especially important at Tijuana Estuary where fish are prey to endangered birds such as the California least tern and the light-footed clapper rail (Zedler and Nordby 1986; Zedler et al. 1992).

Historically, the Tijuana Estuary has supported a diverse fish assemblage. Prior to an El Niño-related flood event in 1980, this area supported as many as 29 species of fish. However, flooding reduced salinity to 0 ppt and samples collected after that time demonstrated decreased fish diversity (Zedler and Nordby 1986).

In 1984, the estuary mouth was closed for approximately eight months. Inlet closure resulted in hypersalinity which affected fish directly by causing physiological stress and indirectly by eliminating food. Fish surveys conducted six months after inlet closure, at which time salinity was as high as 60 ppt, demonstrated that diversity had decreased. Until 1979, California halibut

(*Paralichthys californicus*), diamond turbot (*Hypsopsetta guttulata*), and staghorn sculpin (*Leptocottus armatus*) had been reported as abundant. Due to hypersaline conditions created by mouth closure, these dominant fish species were replaced by fish with wide salinity tolerances (Zedler and Nordby 1986).

Between the years 1986 and 2002, 33 species of fish were recorded compared based on regular sampling. A survey of fish conducted by the Pacific Estuarine Research Laboratory (PERL) during the 2001-2002 season demonstrated that arrow goby (*Clevelandia ios*) and topsmelt (*Atherinops affinis*) were the dominant species, followed by California killifish (*Fundulus parvipinnis*). Yellowfin goby (*Acanthogobius flavimanus*), a native of Japan that has become established in the San Francisco Bay, was also observed but is considered rare at Tijuana Estuary. California halibut, diamond turbot, and staghorn sculpin, once abundant at Tijuana Estuary, cumulatively represented 0.5% of fish surveyed according the survey conducted by PERL. A list of all fish species observed in the Tijuana Estuary is presented in Appendix C.

7.2.5 Benthic Invertebrates

Much like fish, benthic invertebrates are essential to wetlands due to their role in nutrient cycling and because, as prey items, they also have the potential to transfer energy from a marine environment to a terrestrial environment. They are especially important at Tijuana Estuary where benthic invertebrates are prey to migratory shorebirds, such as the long-billed-curlew (*Numenius americanus*), a Federal Species of Concern.

In his 1977 study of bivalve molluscs, Hosmer observed 16 species of bivalves at Tijuana Estuary. At this time, the purple clam (*Sanguinolaria nuttallii*) was the dominant bivalve species. This clam was observed both in the northern and southern arms in sands ranging from very coarse to fine (Hosmer 1977). The littleneck clam (*Protothaca staminea*) was the second most abundant species. According to Homziak (1977), the ghost shrimp was the dominant crustacean at the estuary.

Prior to 1980, more than 75 species of invertebrates were found at the estuary. However, habitat degradation due to mouth closure and freshwater input from transborder sewage flows resulted in decreased diversity of benthic invertebrate species (Zedler and Nordby 1986). The eight-month closure of the estuary mouth resulted in the extirpation of all bivalves and of several other species. Only the presence of spionid worms and epibenthic gastropods was demonstrated by sampling conducted during this time (Nordby 1987). The diversity of the bivalve population increased after tidal flushing was reinstated in December 1984, with the colonization of several bivalve species at the estuary. Littleneck clams and California jackknife clams were the dominant species after the opening of the estuary mouth (Entrix et al. 1991). Freshwater input from sewage inflow in 1986 resulted in further impacts to invertebrate diversity. Purple clam, a once abundant species, has not been observed since the 1984 mouth closure (Entrix et al. 1991). During collections conducted by PERL from 2001-2002, sixty-two invertebrate taxa were observed. Dominant taxa observed included polychaetes, bivalves and molluscs followed by crustaceans and gastropods (PERL 2002).

In 1988, benthic sampling was conducted in the southern arm (Entrix et al. 1991). It was determined that the northern arm had higher species diversity than the southern arm. In the northern channels, species composition changed as distance from the estuary mouth increased, demonstrating higher species variability. In the southern channel, species diversity was lower and species composition did not appear to vary with distance from the mouth. The hydrologic differences between these two channels may account for species composition and diversity differences. Changes in sediment quality in the northern channel allow for a mostly heterogeneous channel bottom. The southern channel, however, had relatively poor tidal flushing and a mostly homogeneous channel bottom dominated by fine sediments (Entrix et al. 1991). Today, tidal flushing is substantially reduced from 1988 as a result of sediment deposition. A list of invertebrate species is included in Appendix C.

7.2.6 Insects and Arthropods

Insects serve as an important source of prey, pollinators to plants, and predators that aid in the management of potentially detrimental species (Atkins 1971; Daly et al. 1978). They are especially important at Tijuana Estuary where small flying insects are prey to sensitive birds, such as the western snowy plover. Areas of California cordgrass-dominated salt marsh have been known to support up to eleven orders of arthropods, with flies (Diptera) being the most abundant (Williams et al. 1989). Eleven orders of arthropods were also observed in areas of pickleweed-dominated mid-marsh habitat, with flies (Diptera) also being the most common (Williams et al. 1989). Two sensitive insects, including globose dune beetle (*Coelus globosus*) and wandering skipper (*Panoquina errans*) were observed during surveys conducted in 1988 (Williams et al. 1989). In addition, rare insects were including Gabb's tiger beetle (*Cicindela* gabbi), mudflat tiger beetle (*C. trifasciata sigmoidea*), sandy beach tiger beetle (*C. hirticollis* gravida), and sand dune tiger beetle (*C. latesignata latesignata*), are known to occur at the estuary (Nagano 1982). The status of each of these species and the potential impacts from restoring the southern arm of the estuary are presented in Section 7.3 Sensitive Species.

A healthy insect population is important to several coastal plant species. The federally and state endangered salt marsh birds' beak (*Cordylanthus maritimus* ssp. *maritimus*) depends on at least five potential flies and bees to function as pollinators. These fly and bee species are believed to nest in salt flats and high transition zone areas with mammal burrows (Entrix et al. 1991). Insects and arthropods observed in the project vicinity are presented in Appendix C.

7.3 Sensitive Species

Sensitive species are those that have been listed as such by federal or state resource agencies, or by special interest groups such as the California Native Plant Society (CNPS). At least twenty sensitive species are known to occur within the project area in the Tijuana Estuary. These include four plants, one insect, three reptiles, eleven birds, and one mammal.

7.3.1 Sensitive Plants

While a number of sensitive plant species have been reported from the Tijuana River Valley, only four have the potential to occur in the project area. These include the federally and state endangered salt marsh birds' beak (*Cordylanthus maritimus* var. *maritimus*) Nutall's lotus (*Lotus nuttallianus*), a CNPS list 1B species; Coulter's salt marsh daisy (*Lasthenia glabrata* ssp. *coulteri*), a CNPS list 1B species; and estuary seablite (*Suaeda esteroa*), a CNPS List 2 species (CNPS 2001). Focused surveys for the plant species listed above were conducted within the project area during the appropriate blooming periods. The biology of potentially occurring sensitive species is presented below.

<u>Salt marsh bird's beak</u>
Federal Status: Endangered
State Status: Endangered

Salt marsh bird's beak, a member of the Scrophulariaceae or buckthorn family, is a hemi-parasitic annual herb ranging from 10 to 40 centimeters in height (Hickman 1993). Although this plant is not host specific, it is habitat specific. It typically occurs in upper salt marsh in partially shaded areas that have reduced soil salinity in spring and do not impound water for more than 24 hours. This plant is often tinged purple and produces dense and ascending flowering branches that are salt-encrusted (Hickman 1993). It flowers from May to October producing flowers that are white to cream colored with lips that are pale brown or purplish red. Salt marsh bird's beak is known to occur in coastal salt marsh and coastal dunes. This species is threatened by vehicles, road construction, foot traffic, and loss of salt marsh habitat (CNPS 2001).

A population of salt marsh bird's beak was reported as occurring west of the southwestern portion of the project area (ENTRIX et al., 1991; Figure 7-3). A focused survey for this species was conducted by Tierra on August of 2004 in the vicinity of the 1991 observation. In addition, all areas of appropriate high marsh habitat within and adjacent to the project area were surveyed. Surveys were conducted by walking roughly parallel transects approximately 30 feet wide. Prior to conducting the surveys, an existing colony of salt marsh bird's beak that occurs in the northern arm of the estuary was studied as a reference site. The colony was robust and in flower at the time of the survey.

The salt marsh bird's beak population reported in 1991 was not observed during the 2004 survey. At this point it is assumed that this population is no longer extant. Furthermore, no salt marsh bird's beak was observed during the survey, although seemingly appropriate habitat was abundant. Shoregrass (*Monanthochloe littoralis*), one of the host plants of this hemi-parasitic species, was abundant throughout the westernmost portion of the survey area.

<u>Estuary seablite</u>
Federal Status: None
State Status: None
CNPS List 1B

Estuary seablite is a perennial plant that belongs to the Chenopodiaceae or goosefoot family. This plant grows from 10 to 60 cm in height (Hickman 1993) and blooms between May and October. Appropriate habitat for this species consists of coastal salt marsh habitat.

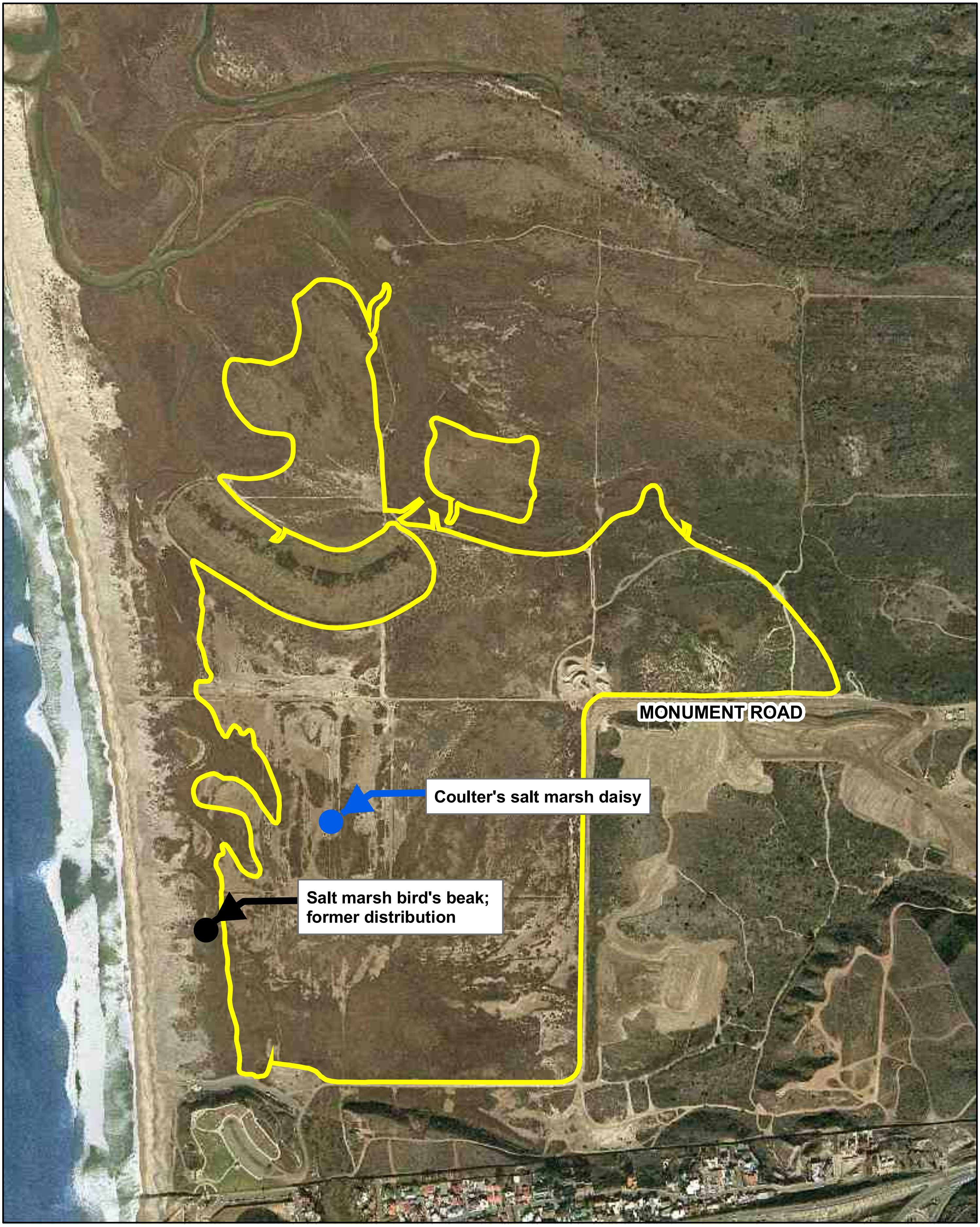

FIGURE 7-3

Sensitive Plant Species Occuring in the Vicinity of the Project Area

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A focused survey for estuary seablite was conducted in June of 2004. Survey methods involved walking transects approximately 30 feet wide throughout areas supporting coastal salt marsh, concentrating along the wetter margins of channels and ponded areas suitable for seablite.

A small group of group of this plant species was observed outside of the project area; however, none were observed in the project area. This species is common in the northern arm of the estuary which receives regular tidal flushing. The group observed during the focused survey was located near the mouth, suggesting that reduced tidal flushing in the southern arm may be affecting the biodiversity of that portion of the estuary.

<u>Nuttall's lotus</u>
Federal Status: None
State Status: None
CNPS: List 1B

Nuttall's lotus, a member of the Fabaceae (pea) family is a perennial herb that blooms between March and June (CNPS 2001). This annual herbaceous plant occurs in coastal dune and sandy coastal scrub habitats. The decline of this species is the result of development and the introduction of exotic plant species.

Nuttall's lotus is known to occur in sandy beach habitat located west of the project area. A small patch of Nuttall's lotus located immediately outside of the project area was observed during a focused survey in April of 2005.

<u>Coulter's salt marsh daisy</u>
Federal Status: None
State Status: None
CNPS: List 1B

Coulter's salt-marsh daisy is a member of the Asteraceae or sunflower family. This annual species can grow up to 60 cm in height and can be simple or branched and ranges from glabrous to slightly hairy (Hickman 1993). The blooming period occurs between February and June, during which yellow-ray and yellow-disc flower heads are produced. This species is known to occur in the upper portions of tidal marsh areas near the coast. It has also been observed near the edges of vernal pools at Miramar Airfield (Reiser 1994). Herbarium collections include specimens from Tijuana River Valley, the east end of Mission Bay, and the mouth of the Sweetwater River. However, it is not know if these populations are extant (Reiser 1994).

Coulter's salt-marsh daisy was not observed during focused sensitive plant surveys conducted in June of 2004. However, a small area supporting this plant species was observed within the southwestern portion of the project area during a vegetation survey conducted on March of 2005 (Figure 7-3). Coulter's salt-marsh daisy has been observed at the northern arm of the estuary (C. Nordby pers. comm.).

7.3.2 Sensitive Wildlife

Globose dune beetle
Federal Status: Federal Species of Concern
State Status: None

The globose dune beetle occurs in California's coastal foredunes and sand hummocks. These beetles tunnel through sand beneath dune vegetation, as they are primarily subterranean. This beetle is believed to feed on the roots of native dune plants (Entrix et al. 1991). Although the dune beetle is relatively abundant, its habitat is increasingly limited.

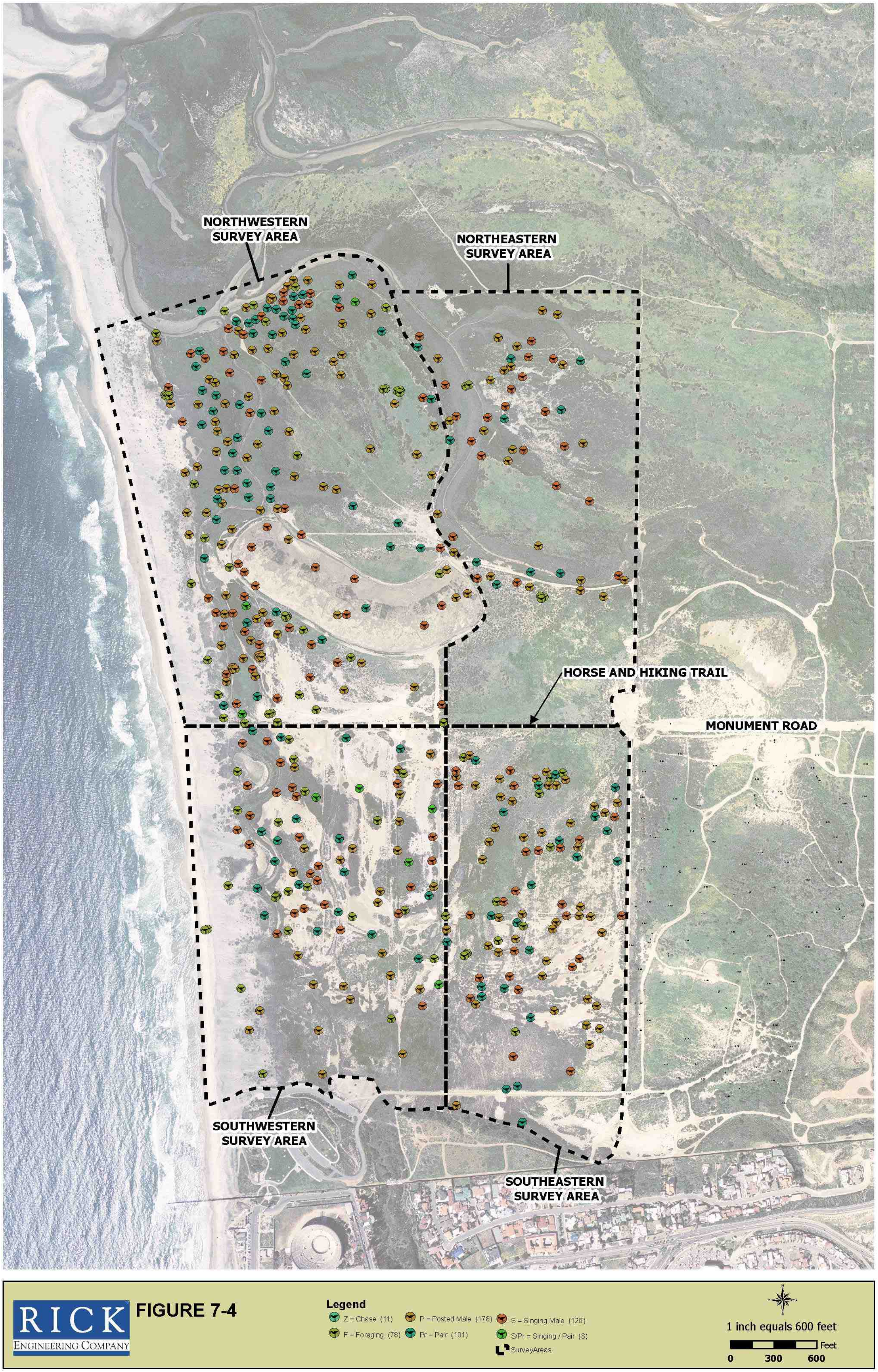
Very low numbers of globose beetles were found along the south barrier beaches in August 1982 (Nagano 1982).

Belding's savannah sparrow
Federal Status: None
State Status: Endangered

The Belding's savannah sparrow (*Passercullus sandwichensis beldingi*) is a member of the Emberizidae family. This small dark brown songbird is heavily streaked, with distinctive black streaks on white breast, back color tinged with olive green, and yellow wash to the lores and face (Rising 1996, Unitt 2004). A year-round resident of southern California, the Belding's savannah sparrow nests and forages almost exclusively in the coastal salt marsh environment dominated by pickleweed (*Salicornia virginica*). Nests are usually built in natural depressions in the ground and are concealed by overhanging vegetation (Wheelright and Rising 1993). The decline of the Belding's savannah sparrow can be attributed to habitat loss resulting from the development of the southern California coastline.

Appropriate habitat for this species occurs throughout much of the project area. Furthermore, this species was observed during general biological surveys and is the most prominent species in the project area. Therefore, it was determined that focused surveys for this species were necessary. Focused surveys were conducted in the spring of 2004. The purpose of these surveys was to determine the distribution of Belding's savannah sparrow within what was then defined as the proposed project area. The 2004 survey included areas that were subsequently eliminated from the restoration plan. Consequently, the data are presented in two ways: 1) for the entire area surveyed, and 2) for the final Preferred Project Area.

The 2004 survey area was divided into four sub-areas: the northeastern area, northwestern area, southeastern area and southwestern area (Figure 7-4). Each of the four areas was surveyed by R. Patton, J. Barth, E. Alfaro, and M. Alfaro in one day. Survey dates, times and weather conditions are summarized in Table 7-1 and Appendix C. Areas were surveyed along transects approximately 100 feet wide. Belding's savannah sparrow observations were made with the use of binoculars and were mapped onto a 1 inch = 350 foot aerial photograph of the project area.



Results of 2004 Focused Belding's Savannah Sparrow Survey for Expanded Survey Area

Seven categories were used to describe sparrow behavior: Call (C), Foraging (F), Posted Male (P), Pair (Pr), Singing Male (S), Chase (Z), and Singing Male/Pair (S/Pr). Sparrow behavior associated with each of these categories is summarized in Table 7-2.

The results of the surveys conducted in 2004 are presented in Figure 7-4 and summarized in Table 7-3. Individuals demonstrating behaviors such as calling and foraging were not counted as representing breeding pairs because they may have been counted elsewhere in territories or may represent young of the year (Zembal and Hoffman 2002). Individuals observed in chases were interpreted as representing at least one territory or breeding pair.

Individuals involved in singing or prolonged posting indicated territoriality but may have included both members of a pair. For this reason, an estimated index of breeding adult pairs was calculated. The estimated index ranges from 50% of observations of Singing and Posted behaviors to the total number observed. Thus, a minimum of 110 pairs (102Pr, 8S/Pr) of Belding's savannah sparrows were observed, and an index of breeding pairs was estimated to range from 271 to 419 (Table 7-3).

Table 7-1. 2004 and 2005 Belding's Savannah Sparrow Focused Survey Conditions

Date	Time	Survey Area	Weather Conditions
April 14, 2004	0840 to 1240	Southeastern	68° F, 10% cloud cover, 2 mph winds
April 27, 2004	0830 to 1245	Southwestern	72° F, 10% cloud cover, 2 to 5 mph winds
April 28, 2004	0700 to 1330	Northwestern	59° F, 60% cloud cover, 5 to 10 mph winds
April 29, 2004	0700 to 1330	Northeastern	59° F, 100% cloud cover, 6 to 10 mph winds
May 6, 2005	0700 to 1030	Southwestern and Southeastern	63° F, 80% cloud cover, 2 to 5 mph winds

Table 7-2. Belding's Savannah Sparrow Behavioral Categories

Behavior	Description
Z	Sparrow chasing another sparrow out of his territory
C	Sparrow calling
F	Sparrow foraging, does not discern the sex of the individual
P	Sparrow posted for an extended period on a high point of pickleweed (*Salicornia* sp.)
Pr	Two sparrows in close proximity of one another (three feet or less), not displaying aggressive or territorial behaviors towards each other
S	Sparrow observed singing
S/Pr	Sparrow singing and a second sparrow in close proximity

Table 7-3. 2004 Belding's Savannah Sparrows Focused Survey Results

Behavior	Number of Observations	Observed Individuals	Estimated Pair Index
C	0	0	0
Z	11	22	11
F	78	78	0
P	178	178	89-178
Pr	102	204	102
S	120	120	60-120
S/Pr	8	16	8
Total	**497**	**618**	**271-419**

Using the footprint of the Preferred Alternative as the survey area, a total of 220 observations were recorded representing at least 45 pairs (41Pr, 4S/Pr) and an estimated index of approximately 116 to 179 pairs of Belding's savannah sparrows (Figure 7-5 and Table 7-4). For the purpose of determining what proportion of sparrow pairs occur within the Preferred Project Area, the midpoint of the estimated index was calculated. This assumes that 75% of posted and singing males comprise a pair. Under this assumption, 147 Belding's savannah sparrow pairs were estimated to occur within the project boundaries in 2004 (Table 7-4).

Within the project area, the highest density of Belding's savannah sparrows was observed south of the existing horse trail to the beach and west of Monument Road (Figure 7-5). This area accounted for approximately 75% of the observations of Belding's savannah sparrow observed within the footprint of the Preferred Project.

Table 7-4. 2004 Belding's Savannah Sparrows within the Project Area

Behavior	Number of Observations	Observed Individuals	Estimated Pairs
C	0	0	0
Z	8	16	8
F	42	42	0
P	78	78	39-78
Pr	41	84	41
S	47	47	23-47
S/Pr	4	8	4
Total	**220**	**275**	**115-178**

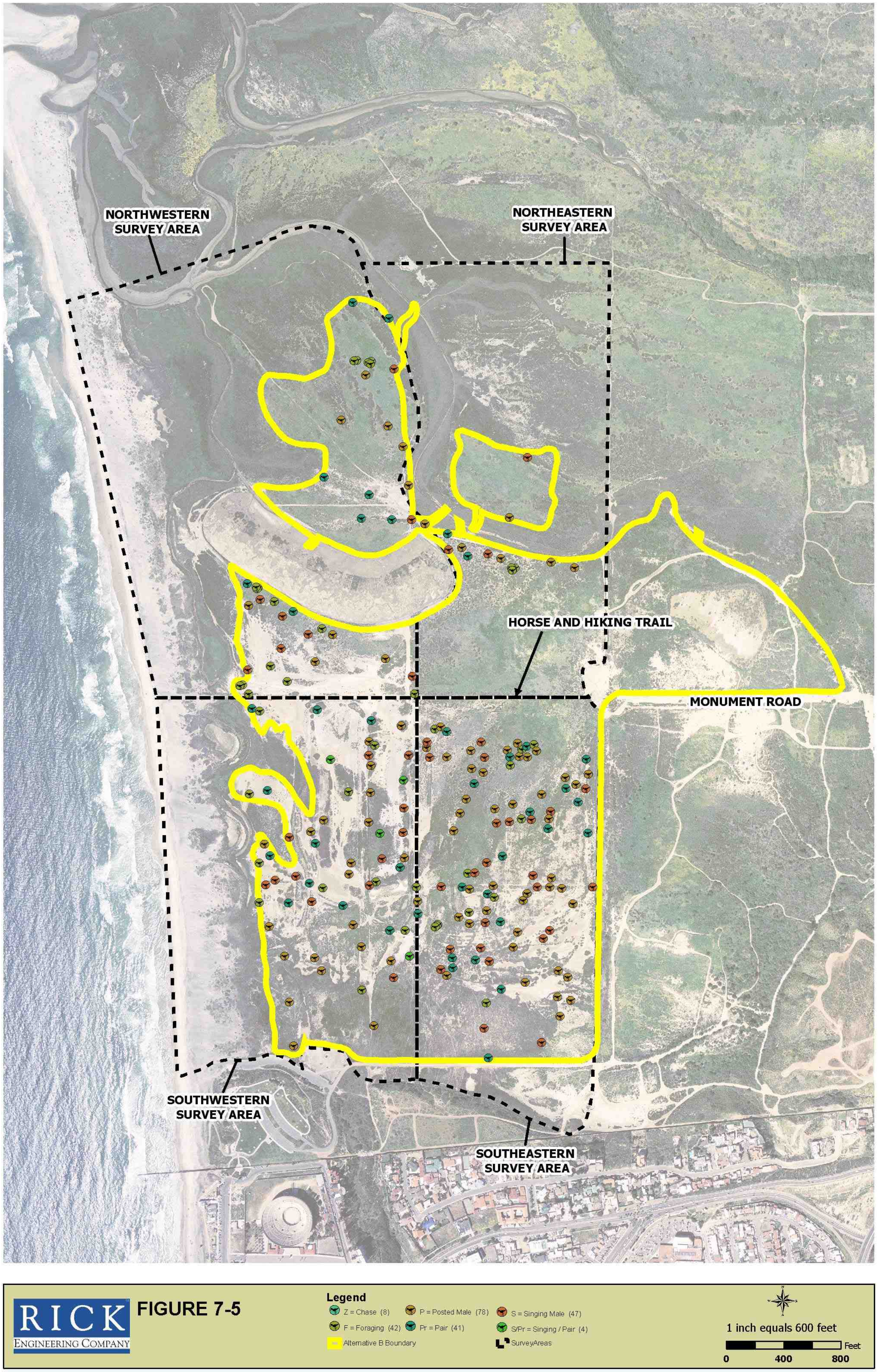


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FIGURE 7-5

Belding's Savannah Sparrow Distribution within the Project Area, 2004

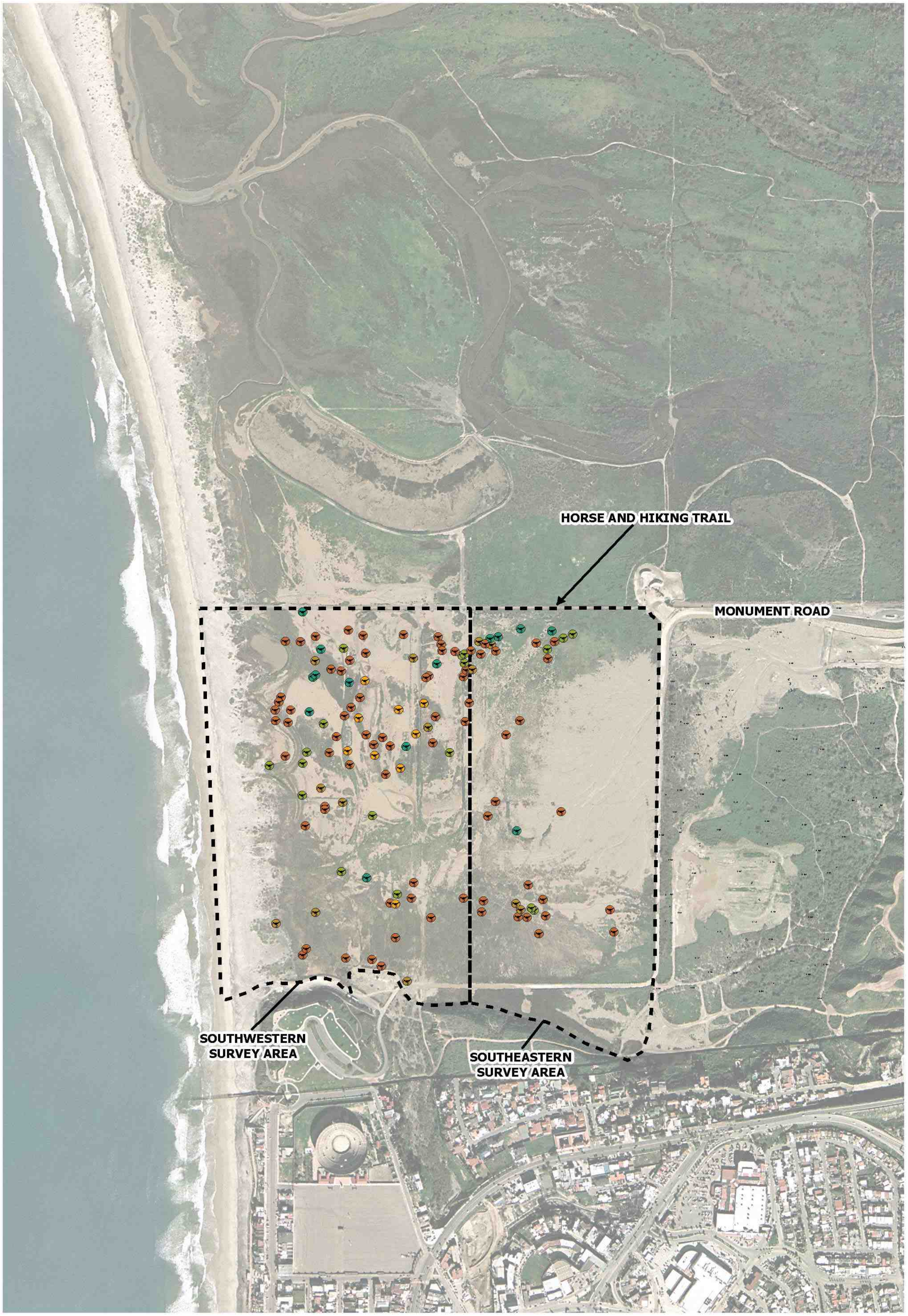
As presented previously, heavy rainfall during January of 2005 resulted in the deposition of large amounts of sediment within the area located south of the horse trail and bound by Monument Road. Consequently, areas that once supported disturbed coastal salt marsh habitat now support disturbed mule-fat scrub or are devoid of vegetation.

Approximately 40% of disturbed salt marsh habitat occurring within the southeastern survey area was destroyed by sediment during this catastrophic storm event. An additional 30% of this habitat was converted to disturbed brackish marsh. Therefore, approximately 70% of disturbed salt marsh habitat observed in the southeastern survey area was lost as a result of the storm and continued freshwater inflow. Subsequently, it was determined that a focused survey for Belding's savannah sparrow should be conducted in the affected area to determine the effects of this event on this species. Figure 7-6 shows the area of sediment deposition prior to colonization by mule-fat and weedy species.

A focused Belding's savannah sparrow survey of the southeastern and southwestern sub-areas (representing the Preferred Project footprint) was conducted on May 6, 2005. The same survey methods and behavior categories that were used during the 2004 surveys were used during the 2005 surveys.

All Belding's savannah sparrow individuals detected were mapped onto an aerial photograph of the site. The results of this survey are illustrated in Figure 7-6. During the 2005 survey, a total of 132 savannah sparrow observations representing a minimum of 14 pairs and an estimated index of 65 and 113 pairs were detected within the entire survey area. During the 2004 survey, observations made within the southwestern and southeastern survey areas totaled 207 and represented a minimum of 55 pairs and an estimated index of 111 and 186 pairs.

During the 2004 survey, the minimum number of pairs of sparrows recorded within the southeastern area was 22, and the estimated index ranged between 62 and 95 pairs (Table 7-5). During the 2005 surveys, a minimum of 5 pairs and an estimated index between 18 and 30 pairs of Belding's savannah sparrows were recorded within the same area. Comparatively, the number of pairs of sparrows recorded within the southwestern area during the 2004 survey was a minimum of 23 pairs (18Pr, 5S/Pr) with an estimated index that ranged between 49 and 76. During the 2005 surveys, the number of pairs recorded decreased to a minimum of 9 pairs and an estimated index ranging between 47 and 83. Thus, approximately 70% of the pairs of sparrows observed within the southeastern area during the 2004 surveys were displaced by sedimentation caused by the storm. The loss of pairs of sparrows appears to be correlated to the loss of 70% of salt marsh habitat occurring within the southeastern area. The decrease observed in the southeastern area was not observed in the southwestern area. It is assumed that because an increase in pairs was not observed in the southwestern area, that displaced sparrows have perished or have moved to the northern survey areas. Belding's savannah sparrow observations in the southwestern and southeastern survey areas during the 2004 and 2005 surveys are compared in Table 7-5. During construction of the proposed project this species may be impacted, as individuals utilizing disturbed saltmarsh habitat within the Preferred Project Area would be displaced. However, the project will be constructed in phases that will potentially leave habitat for displaced individuals. Overall, the project is expected provide high quality habitat for a minimum of 198-215 individual Belding's savannah sparrows.



RICK ENGINEERING COMPANY

FIGURE 7-6

Legend

C = Call (9)
P = Posted Male (13)
S = Singing Male (77)
F = Foraging (18)
Pr = Pair (14)

1 inch equals 600 feet

0 300 600 Feet

Results of 2005 Belding's Savannah Sparrow Surveys; Southern Portion of the Project Area

Table 7-5. 2004 vs. 2005 Belding's Savannah Sparrow Survey Results, Southeastern and Southwestern Survey Areas

	Southwestern Survey Area						Southeastern Survey Area					
	Number of Observations		Observed Individuals		Estimated Pairs		Number of Observations		Observed Individuals		Estimated Pairs	
Behavior	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
C	0	9	0	9	0	5-9	0	0	0	0	0	0
Z	2	0	4	0	2	0	6	0	12	0	6	0
F	24	13	24	13	0	0	12	5	12	5	0	0
P	25	9	25	9	13-25	5-9	43	4	43	4	22-43	2-4
Pr	18	9	36	18	18	9	22	5	44	10	22	5
S	26	56	26	56	13-26	28-56	24	21	24	21	12-24	11-21
S /Pr	5	0	10	0	3-5	0	0	0	0	0	0	0
Total	**100**	**96**	**125**	**105**	**49-76**	**47-83**	**107**	**35**	**135**	**41**	**62-95**	**18-30**

<u>California least tern</u>
Federal Status: Endangered
State Status: Endangered

The California least tern (*Sterna antillarum browni*) is the smallest member of the Laridae family. This bird is white and gray with relatively long narrow wings, a short tail, and a slightly decurved tapered bill. The California least tern resides in California only during the breeding season, which begins in mid-April and ends in mid-September. The southern extreme of its nesting range occurs near La Paz, Baja California while its northern most nesting range in San Francisco Bay. During the breeding season the least tern will nest on sandy beaches, airports, and landfills adjacent to the ocean or a bay. The least tern is a colonial bird and nests on the ground by creating a small depression in the sand; the cryptic coloration of the eggs makes them difficult to see. Consequently, least tern nests are vulnerable to trampling by humans. Intruders in the nesting colony are mobbed by a collective colony effort. Least terns are monogamous and both parents tend the nest, a pair can have up two clutches per breeding season. The least tern diet consists of very small fish. The decline of this colonial nesting seabird can be attributed to development of the coastline in California.

Surveys of the California least tern colonies at Tijuana Estuary have been conducted for over twenty years and include a census of the number of breeding pairs, nests, chicks, and fledglings produced. Weekly focused surveys of California least tern colonies are conducted each year during the nesting season (R. Patton pers. comm.). Such surveys also allow for the documentation of predator activity within the colony. Coordination between monitors and predator management staff is vital for the survival of the colony.

The results of these surveys reflect a highly variable population that responds to pressure from predation as well as climate and other factors that affect food supply (R. Patton pers. comm.). However, since the commencement of census surveys, the general trend of the tern population at the Tijuana Estuary has been upward. The highest recorded population of California least terns in the project area ranged between 358 and 400 pairs in 2003. Within the past six years, the lowest number of terns was 146 to 190 pairs in 2002. Most recently, the 2005 survey estimated 326-391 nesting pairs (R. Patton pers. comm.). California least tern nesting occurs in the dunes and beaches immediately adjacent to the project area. It is not anticipated that the project will result in any direct impacts to California least tern or their habitat. However, construction within areas adjacent to occupied nesting habitat may be limited to the non-breeding season (September 16-April 14). The project will result in a net benefit to this species by creating additional intertidal and subtidal foraging habitat.

<u>Western Snowy Plover</u>
Federal status: Threatened
State status: Species of special concern

The western snowy plover (*Charadrius alexandrinus nivosus*), a member of the Charadriidae family, occurs as a migrant, winter visitor, and localized breeder in San Diego County (Page et al. 1991, Unitt 1984, 2004). Many of the local populations migrate south for the winter, while the others remain in southern California year-round. The western snowy plover is a small shorebird with dark gray to black legs, a slim black bill, and a black ear patch (Sibley 2000). Its diet consists of small aquatic insects, crustaceans, and soft invertebrates.

The breeding season is typically between mid-March and may extend through September. However, nesting attempts as early as mid-February have been documented. Males build the nest in sandy dunes or mud flats by scraping a small depression in the ground and lining it with dry grass, twigs, and other debris. The plover will often try and conceal its location from predators by adding bits of ornamental debris to the nest (Ehrlich 1988). Consequently, plover nests are vulnerable to trampling by humans. The number of western snowy plovers has steadily decreased due to human development and disturbance of beach habitats (Unitt 1984).

Weekly focused surveys of western snowy plover nesting areas are conducted each year during the nesting season (R. Patton, pers. comm.). Although nesting snowy plovers were documented during least tern surveys, monitoring of snowy plovers in the Tijuana Estuary did not begin until 1994. The numbers of nesting plovers have remained low during this period, with severe population decreases noted in recent years both locally and regionally. A total of eight breeding males were documented as occurring at Tijuana Estuary during the 2005 breeding season (R. Patton 2005). Like the California least tern, the snowy plover nests in the dunes and beach outside of the proposed project area. It is likely that construction of project phases located immediately adjacent to the shoreline will be restricted during the breeding season for this species. However, it is not anticipated that this sensitive species will be directly affected by the restoration project.

<u>Gull-billed Tern</u>
Federal Status: None
State Status: California Special Concern Species

The gull-billed tern (*Sterna nilotica*) is a medium sized tern with long black legs and a thick black bill. This colonial water bird is a summer resident of San Diego County and nests within the San Diego Bay National Wildlife Refuge South Bay Unit, situated approximately four miles northeast of the project area (Unitt 2004). There are only two known gull-billed tern nest sites in the western United States. The second nesting site is located in the Salton Sea. This species nests on the ground constructing its nest in a depression in using large twigs and other detritus. Unlike most colonial waterbirds, the gull-billed tern does not mix with other tern species at roosting sites. In addition, this tern species does not plunge dive for prey items but rather plucks prey items from mudflat, grassland, open scrub, and dune habitats.

During the summer months, this species has been observed foraging at the Tijuana Estuary. Food items include marine invertebrates along the shoreline, small lizards in sparsely vegetated habitats, and on snowy plover and least tern eggs and chicks in dune habitat. This species does not nest at the Tijuana Estuary. Therefore, the proposed project will not impact this species.

Least Bell's Vireo
Federal Status: Endangered
State Status: Endangered

Least Bell's vireo nests in dense willow scrub habitat associated with the freshwater influence of the Tijuana River. In the project area, the nearest least Bell's vireo habitat is located in the alluvial delta associated with Goat Canyon. Up to nine breeding pairs were documented in that area during multi-season spot-mapping surveys conducted for the Goat Canyon Enhancement Project (Tierra Environmental Services, 2000). The proposed project would have a minimal impact on disturbed southern willow scrub habitat. Therefore, the proposed project is not expected to impact least Bell's vireo.

Light-footed Clapper Rail.
Federal status: Endangered
State status: Endangered

Light-footed clapper rails are known to nest in cordgrass-dominated low marsh habitat and forage at the edge of the salt marsh, mudflats and tidal channels. The loss of salt marsh habitat in southern California has threatened this species with extinction. Despite management practices, the status of this species remains critical. It is believed that there are fewer than 600 individuals left in the wild. Tijuana Estuary supports the second largest population of light-footed clapper rail in California. The largest light-footed clapper rail population occurs in Newport Bay.

The light-footed clapper rail population of the Tijuana Estuary has been monitored since 1980. The number of nesting pairs has gradually increased over that period of time; however, much fluctuation also has been observed. In 1983, 41 pairs of clapper rail were observed at Tijuana Estuary. The population declined drastically following closure of the tidal inlet in 1984. At that time, no birds were observed during focused surveys. In 1986, 2 pairs were observed. By 1987 numbers were increasing once again and the population in 1991 reached 47 pairs. It is possible that clapper rails migrated temporarily in response to hyper saline conditions created by inlet closure. Approximately 86 pairs of light-footed clapper rails were detected during a census conducted at the Tijuana Slough National Wildlife Refuge in 2005.

Many salt marsh restoration projects target creation of cordgrass-dominated marsh, the preferred breeding habitat of the light-footed clapper rail. A glimpse of successful salt marsh creation is provided by the Model Marsh. The Model Marsh was part of the first phase of the Tijuana Estuary Tidal Restoration Project (Entrix et al. 1991) and was constructed during the winter of 1999/2000. Five pairs of breeding clapper rails were detected in the 20-acre Model Marsh in Fall 2004.

The proposed restoration project will benefit the light-footed clapper rail by providing intertidal cordgrass-dominated breeding habitat, mid- and high marsh foraging habitat, and mudflat foraging habitat. Based on the current density of clapper rails in the 20-acre Model Marsh, it is estimated that the Friendship Marsh Restoration Project would create habitat for an additional 16-19 pairs of this endangered species. Conversely, construction of the project is not expected to directly impact this species. Phases that adjoin the model marsh would likely be constructed outside of the breeding season (February 15 through September 1). There are no clapper rails south of the model marsh as there is essentially no intertidal marsh in this portion of the project area.

<u>California Brown Pelican</u>
Federal Status: Endangered
State Status: Endangered

The California brown pelican (*Pelecanus occidentalis californicus*) is a member of the Pelecanidae family and is a local, year-round resident of the bays and beaches of California. This bird can be described as a large, dark water bird with much white about the head and neck (Sibley 2000). Adults weigh approximately 8 pounds and have a wingspan of over 6 six ft. The breeding grounds of this colonial nesting and feeding bird occur on open coastal habitat on islands without mammalian predators. Their nests are made of sticks and occur on mangrove treetops or on the ground. Courtship of individuals occurs at the nesting site. The male pelican provides nesting material and the female constructs the nest. Eggs are laid between March and April. Eggs are incubated and chicks reared by both the male and the female.

The diet of the California brown pelican consists primarily of northern anchovy but also includes Pacific mackerel and Pacific sardine (Ehrlich 1988). The decline of northern anchovy populations, due to overfishing by humans, has been detrimental to the California brown pelican. In addition, chronic reproduction problems have persisted since the banning of the pesticide DDT. Some birds continue to show high levels of pesticides in their tissue. The California brown pelican also is threatened by botulism outbreaks and injuries from fishing equipment (USFWS).

Although the California brown pelican occurs within the Tijuana Estuary, appropriate breeding and foraging habitat does not occur within the project area. Therefore, construction of the proposed project will not affect this species.

Burrowing Owl
Federal Status: Species of Concern
State Status: Species of Special Concern

Burrowing owl (*Athene cunicularia*) is small owl with long legs, a short tail, relatively narrow wings, and a flat head (Sibley 2000). It breeds on grasslands, coastal dunes, and open areas near human habitation, especially golf courses and airports. Their diet includes large insects, reptiles, fish, small rodents and small birds (Ehrlich 1988). This species inhabit abandoned mammal burrows, which they occasionally enlarge by kicking dirt backward. Burrowing owls usually nest in small colonies within ground squirrel and prairie dog colonies. Because burrows are usually swarming with fleas they often chose a new burrow 2-4 weeks after young emerge. Populations in the Pacific coast are declining and continue to be threatened by destruction of suitable habitat by urbanization and human efforts to control squirrel and prairie dog populations with the use of poison (Unitt 1984).

Burrowing owls are known to nest in dune habitat adjacent to the project area. Burrowing owls were not observed in the project area and area not expected to occur. Construction of phases that adjoin the beach may be constrained during the nesting season of this species (February 1 through August 31) if this species is present.

Northern Harrier
Federal Status: None
State Status: Special Concern Species

The northern harrier (*Circus cyaneus*) is described by Sybley (2001) as a slender raptor, with an owl-like facial disc. This species forages by flying low to the ground over grassland and marsh habitat, preying on small birds and mammals. Northern harriers nest on the ground, building nests utilizing sticks, grass and other vegetative material. The decline of this species in San Diego County can be attributed to the urbanization of floodplains (Unitt 2004).

At Tijuana Estuary, at least three nests were documented within the project area during Belding's savannah sparrow surveys conducted in 2004 (R. Patton pers. comm.). Much of the project area provides nesting and foraging habitat for this species. However, appropriate open, low-growing habitat is abundant north of the project area within what has been defined as the effective flow of the Tijuana River. Thus, the project is not expected to result in significant impacts to this species.

White-tailed Kite
Federal Status: Species of Concern
State Status: California Fully Protected Species

The white-tailed kite (*Elanus leucurus*) is a member of the Accipiter family. This species is distinguished from other kites by its white tail, dark wrist spot, pale gray back, and black shoulders (Sibley 2000). Nesting habitat for this bird species includes riparian woodland, marsh habitat, partially cleared or cultivated fields and grassy foothills (Erlich et al.1988). However the white-tailed kite nests in trees and not on the ground.

White-tailed kite is not expected to nest on-site, as trees do not occur within the project area. Foraging habitat for this species occurs within the project area; however, open habitat supporting small mammals, a main prey source for the white-tailed kite, is abundant in the river valley.

California Horned Lark
Federal Status: None
State Status: Special Concern Species

The California Horned lark (*Eremophila alpestris actia*) is fairly slender and long-winged, with a short, stout bill and square tail (Sibley 2000). The California horned lark is one of several subspecies of horned lark in North America. A year round resident of San Diego County, it breeds in suitable habitat throughout the county (Unitt 1984). The range of this subspecies in San Diego County begins on the coast and extends east to Montezuma Valley, La Puerta Valley, and Jacumba (Unitt 1984). The California horned lark can be found on sandy ocean or bay shores, on bare ground or among low herbaceous plants, on mesas or in disturbed areas, in grassland in open agricultural land, and in sparse creosote brush scrub.

California horned lark nest in dune habitat adjacent to the project area. This species is not expected to occur within the project area. Construction of phases that adjoin the beach may be constrained during the nesting season of this species (March 15 through August 31).

Long-billed curlew
Federal Status: None
State Status: Species of Special Concern

The long-billed curlew (*Numenius americanus*) is approximately 23 inches in length, making it the largest shorebird in North America. This shorebird can be described as having a buffy colored body with a cinnamon underwing. Its extremely long bill distinguishes this bird from other species and gives it its name. The long-billed curlew is a common fall migrant and winter visitor of San Diego becoming more uncommon during the summer months and can be observed in tidal mudflats, salt marshes, agricultural fields, and fields of grass.

This species is known to occur in tidal areas in the vicinity of the project area. Although observed within the survey area, this species does not occur in the project area which lacks tidal influence.

Golden Eagle
Federal Status: None
State Status: Species of Special Concern; Fully Protected

The golden eagle (*Aquila chrysaetos*) can be described as a large bird with brown plumage, a golden colored nape (Sibley 2000). With a length of 30 inches and a wingspan over 6.5 feet the golden eagle is one of the largest raptors in San Diego County. In San Diego County this species can be observed soaring over a variety of habitats. However, the preferred hunting grounds include grassland and broken chaparral or sage scrub. Breeding pairs typically will construct their nest in a natural crevice or a ledge on a cliff. However a tall tree situated on a steep slope that offers a commanding view may also be appropriate nesting habitat.

The golden eagle is a regular visitor of the Tijuana River Valley during the non-breeding season (Unitt 2004). This species has been observed foraging in disturbed salt marsh habitat and transitional habitat on-site. However, impacts to this species are not anticipated, as there are no nesting records in the project vicinity.

7.4 Proposed Project Impacts

Construction of the Preferred Alternative would result in impacts to approximately 259.13 acres and would affect 17 habitat types. Proposed project impacts and habitat creation are presented in Table 7-6 and illustrated on Figure 7-7.

Table 7-6. Anticipated Project Impacts and Proposed Conditions

Impacts to Existing Conditions (Acres)				Proposed Conditions	
	Project Component				
Habitat Type	***Basin**	**Berm**	**Total**	**Habitat Type**	**Acres**
Salt marsh fleabane scrub	0.56	0	0.56	Low-marsh	60.03
Brackish marsh	0.01	0	0.01	Mid-high marsh	61.32
Disturbed brackish marsh	45.44	0	45.44	Mudflat	60.66
Disturbed mule-fat scrub	44.75	2.09	46.84	Sub-tidal	61.15
Mule-fat scrub	1.84	0	1.84	Transition	7.11
Tidal channel	0.02	0	0.02		
Disturbed southern willow scrub	0.89	0.03	0.92		
Southern coastal salt marsh	2.37	2.17	4.54		
Disturbed southern coastal salt marsh	58.99	2.99	61.98		
Disturbed salt panne	20.43	0	20.43		
Transitional habitat	4.16	1.37	5.53		
Disturbed upland	22.41	0.11	22.52		
Non-native grassland	17.08	0.04	17.12		
Saltbush scrub	2.73	0	2.73		
Ruderal	20.15	0	20.15		
Tamarisk	0.45	0	0.45		
Disturbed	7.93	0.06	7.99		
Developed	0.06	0	0.06		
Total	**250.27**	**8.86**	**259.13**	**Total**	**250.27**

* Basin refers to all sub-tidal, tidal, mudflat, low-marsh, mid-high marsh and transitional habitats; approximately 250 acres

FIGURE 7-7 Vegetation Communities Occurring within the Project Footprint, 2005

As previously presented, vegetation communities occurring within the project area have been subject to continual disturbance and, as a result, are degraded. Based on studies conducted over the past several years, the loss of wetland habitat and loss of species, such as salt marsh bird's beak has been documented within the project area. It is not anticipated that the area will restore itself naturally. Instead, it is expected that the area will continue to deteriorate and that the biological diversity associated with the Tijuana Estuary will be lost. Therefore, although the construction of the proposed project will result in impacts to existing habitats that, by name, are considered sensitive by the resource agencies, once completed, the area will support higher quality habitat and increased populations of sensitive plant and animal species.

7.4.1 Sensitive Habitats

Nearly all of the habitats listed in Table 7-6 are considered sensitive by one or more resource agency. Existing wetland habitats that would be impacted include salt marsh fleabane scrub, brackish marsh, disturbed brackish marsh, mule-fat scrub, disturbed mule-fat scrub, tidal channel, disturbed southern willow scrub, southern coastal salt marsh, disturbed southern coastal salt marsh, disturbed salt pane and transitional habitat. However, much of disturbed brackish marsh, disturbed mule-fat scrub, non-native grassland, disturbed upland habitat, and transitional habitat occurring within the project area are the direct result of renegade sewage flows and sedimentation. Prior to the colonization by mule-fat and freshwater species, these areas were dominated by salt tolerant hydrophitic plant species and salt panne. Thus, although the current plant assemblages may be considered sensitive, in actuality they are the result of sedimentation and freshwater flows at the cost of more valuable coastal salt marsh.

Typically, the resource agencies seek to protect remnant wetland resources. However, as it has been stressed throughout this document, those remnant wetland resources have been degraded and continue to be degraded by sediment deposition and colonization by non-native plant species. Without active restoration and habitat management, these resources will continue to deteriorate and will be replaced by weedy, upland sites with little value compared to healthy tidal wetland systems. As stated above and in detail in Section 12.0 Project Phasing and Construction Alternatives Analysis, the project will be phased so that it is self-mitigating.

The project will be constructed in phases with Phase 1 proposed for the area impacted by sedimentation in January 2005. It has been documented that this area was formerly salt marsh/salt panne and is now highly disturbed mule-fat scrub. It has also been presented that this site was formerly, but is not currently, occupied by Belding's savannah sparrow. Therefore, the first phase of the overall restoration will entail constructing inter-tidal wetlands, open water and mudflat that will provide habitat to a suite of wetland species, including Belding's savannah sparrows. Thus, the first phase of this restoration project is considered self-mitigating. The habitat created in the first phase together with that created at the 20-acre Model Marsh, will provide habitat to fauna displaced during the construction of Phase 2. For details on construction phasing, see Section 12.0 Project Phasing and Construction Alternatives Analysis.

7.4.2 Sensitive Species

Based on Belding's savannah sparrow surveys conducted in 2004, impacts to disturbed southern coastal salt marsh supporting up to approximately 147 pairs of Belding's savannah sparrow are anticipated. It should be noted, however, that the January 2005 storm event resulted in the displacement/relocation of sparrows located in the southeastern area. Primarily marginal habitat occurs within the northern portion of the project area. Therefore, it is likely that fewer than 147 pairs of sparrows currently inhabit the project area. Areas of disturbed salt marsh habitat are quickly transforming into mule-fat scrub, brackish marsh and non-native grassland. Consequently, the quality and size of available habitat to sparrows is decreasing over-time. The project will be constructed in phases, leaving habitat for displaced individuals. Project construction will begin during the fall, once the breeding season has concluded. Based on the comparison of habitats and sparrow distribution between 2004 and 2005 seasons and Powell and Collier's study (1998) of impacts of habitat degradation and fragmentation, it has been estimated that the restored marsh could support 2-3 times the number of Belding's savannah sparrow as occurred in the project area in 2004 (R. Patton pers. comm.).

Clapper rail currently inhabit the Model Marsh. Phase 1 will create a large area supporting appropriate habitat for this species. This area will include a connector channel to the Model Marsh so that it is accessible to rails. Only Phases 2 and 3 will directly adjoin the Model Marsh. Construction of these phases will likely be restricted to the non-breeding season. Please see Section 12.0 for details on project phasing and construction alternatives.

8.0 SUBSTRATE CHARACTERIZATION

The characterization of sediments within the proposed project area was prepared by AMEC Earth and Environmental, Inc. (AMEC). The results of this characterization are summarized below. This summary was prepared by Tierra and any errors or omissions are the responsibility of Tierra. Two reports were prepared by AMEC and are presented in their entirety in Appendices D and E.

A major component of the Tijuana Estuary-Friendship Marsh Restoration Feasibility and Design Study involves the determination of the current physical and chemical characteristics of the soils and sediments to be excavated. The characteristics of the material to be removed will determine where it can be disposed of and by what methods. The goal of these types of programs is to maximize the beneficial reuse of excavated materials for beach and dune restoration.

The majority of the project area falls under U. S. Army Corps of Engineers (USACE) jurisdiction according to Section 404 of the Clean Water Act. The USACE and US Environmental Protection Agency (EPA) have established procedures for evaluating the suitability of soil and sediments for various disposal alternatives. The guidance document, titled *Evaluation of Dredged Material Proposed for Disposal for Discharge in the Waters of the U.S. – Testing Manual* (referred to as the "Inland Testing Manual"), provides a set of tiered approaches to evaluate the most appropriate inland, beach, or nearshore disposal options (EPA/USACE 1998). If ocean disposal is proposed, sediment testing would be conducted according to the Green Book (EPA/USACE 1991). These sediment evaluation studies are required in order to obtain a disposal permit from the USACE. Permitting is done in conjunction with the EPA and other federal and state agencies. In addition to federal testing requirements, the San Diego Regional Water Quality Control Board (RWQCB) has established waiver criteria in the San Diego Basin Plan for industrial or commercial reuse of dredged material (RWQCB 1998).

For the purposes of this feasibility and design study, sediment was tested to assess:

- Potential chemical contamination of the sediment in the study footprint;
- The grain size and other important physical characteristics of the material;
- The ability of the excavated sediment to support plant life; and.
- The likelihood that significant cultural resources occur in the study area.

The results of this sediment characterization study will be used to identify and permit the most appropriate sediment disposal options, focusing on maximizing the beneficial reuse of excavated or dredged material.

8.1 Existing Data

Coastal plain sediments of Pliocene to Quaternary age underlie the lower Tijuana River, its estuary, and surrounding uplands. The valley floor is underlain by unconsolidated Holocene alluvium generally over 100 feet thick and can be characterized as: (1) fine-grained sediments deposited in the estuary by floods, (2) coarse flood sediments deposited during episodic floods in the alluvial channel of the Tijuana River and from side canyons along the south side of the valley, and (3) coarse coastal sediments deposited by episodic wash-over of the barrier beach and by the capture of littorally transported sands in the tidal inlet by waves and flood tides (Entrix et al. 1991).

Existing information regarding sediment quality (i.e., composition and chemistry) in the Tijuana Estuary is limited to several project-specific reports. The most recent survey conducted in 1999 for the Model Marsh Project used a vibracore to collect sediment samples to a depth of approximately -10 feet at 28 locations (TEG 1999). Results indicated that the top 5 feet of the soil was composed primarily of fine grained sand, too fine for beach nourishment reuse, and that the deeper sediments/soil consisted of fine sand and silt (greater than 50% fines). In addition, observations from trenching activities conducted to test for cultural resources indicated a high degree of both vertical and horizontal stratification, with strata of fine sand or silt common at all locations. Based on the grain size data, it was determined that the majority of available material did not meet USACE criteria for beach nourishment and had to be disposed of at either an upland or deep ocean disposal location.

The Model Marsh study also analyzed samples for chemical contamination. Analyses indicated that values for measured constituents were below the ERL (effects range-low) and ERM (effect range-medium) levels, suggesting that the material could be regarded as contaminant-free. Only low levels of copper, lead, and zinc were detected in the samples. Historical aerial photos indicate agriculture activity in the vicinity of the restoration project which may have contributed to the presence of these heavy metals (Zedler and Nordby 1986). In addition, sedimentation from Goat Canyon historically and currently contributes a large volume of silty fine sands and fine sandy silts, which were probably derived from erosion of the San Diego Formation throughout the lower Tijuana drainage basin (Group Delta Consultants 1999). Given the complex nature of the drainage basin (i.e., development within the basin), it is also possible that some contaminants are carried directly into the southern portion of the reserve from adjacent tributary canyons (de Treville 1984).

8.2 Beneficial Use/Disposal Options

The Clean Water Act mandates that excavated or dredged soils and sediment be assessed for beneficial reuse to the maximum extent practical. A number of beneficial reuse alternatives exist for the material to be excavated as part of this study. These beneficial reuses consist primarily of beach nourishment, nearshore placement for littoral cell replenishment, berm construction within the current project footprint, dune enhancement, and upland contouring and structural fill uses. Other non-beneficial reuse disposal options include placement at the LA-5 ocean disposal site, placement in an overdredged sand pit within the estuary area, disposal at an inactive sand/gravel quarry, and disposal at a municipal landfill.

If the material is determined to be sandy enough, beach nourishment would be the preferred option. The USACE's rule of thumb for beach nourishment suitability is that the material should have 80% of the sediment greater than 0.075 mm in size, and be compatible with the grain size, texture, and color of the sand at the proposed receiver beach. However, these specifications are guidelines and for this study, all sediments greater than .063 mm in size are considered acceptable sands. Finer grained material not suitable for beach nourishment could be used for dike/berm creation, or to fill in over-dredged areas to bring them to grade. The reuse alternatives will be dictated by two factors; 1) the physical properties of the material (e.g., grain size distribution) and 2) the level of chemical contaminants present. The options for disposal of excavated sediments are examined in detail in Section 10. Material Disposal Options.

8.3 Sampling Plan

Because current site-specific data on sediment characteristics within the project area were lacking, a Sampling and Analysis Plan (SAP) was prepared that detailed the proposed sediment collection and testing program to be conducted. This plan included a combination of bulk sediment chemistry and grain size analyses to identify soil/sediment types within the restoration area and included the following elements:

- Preparation of a SAP for agency approval;
- Collection of sediment/soil samples to project depth according to the SAP protocols;
- Chemical analyses on area composite samples;
- Grain size analyses of distinct strata for each core sample;
- Archiving samples for future analysis; and,
- Data analysis and reporting.

AMEC Earth & Environmental, Inc. (AMEC) managed the sediment collection and testing study. The following subcontractors were used in support roles:

- West Hazmat Drilling Corporation provided drilling equipment.
- Calscience Environmental Laboratories, Inc. (Calscience) conducted chemical analyses on composite sediment/soil samples.
- Ninyo and Moore conducted grain size analyses on sediment/soil samples.

8.3.1 Methods and Materials

Sediment Collection Locations

The project was divided into three separate test sites based on past land use patterns and previous studies (Figure 8-1). The easternmost site (Site 1) is an area that has historically been used for agriculture; therefore, some detectable levels of pesticides may be present. Very little information is available regarding the sediment quality and past usage at the northernmost site (Site 2). The southernmost site (Site 3) is in the vicinity of the Model Marsh, where sediment chemistry and grain size data are available from previous studies. In addition, Site 3 contains the area that is most affected by sedimentation and runoff from Goat Canyon. The number of core samples collected from each test site are listed below:

- Site 1 - 7 core samples
- Site 2 - 5 core samples
- Site 3 - 12 core samples

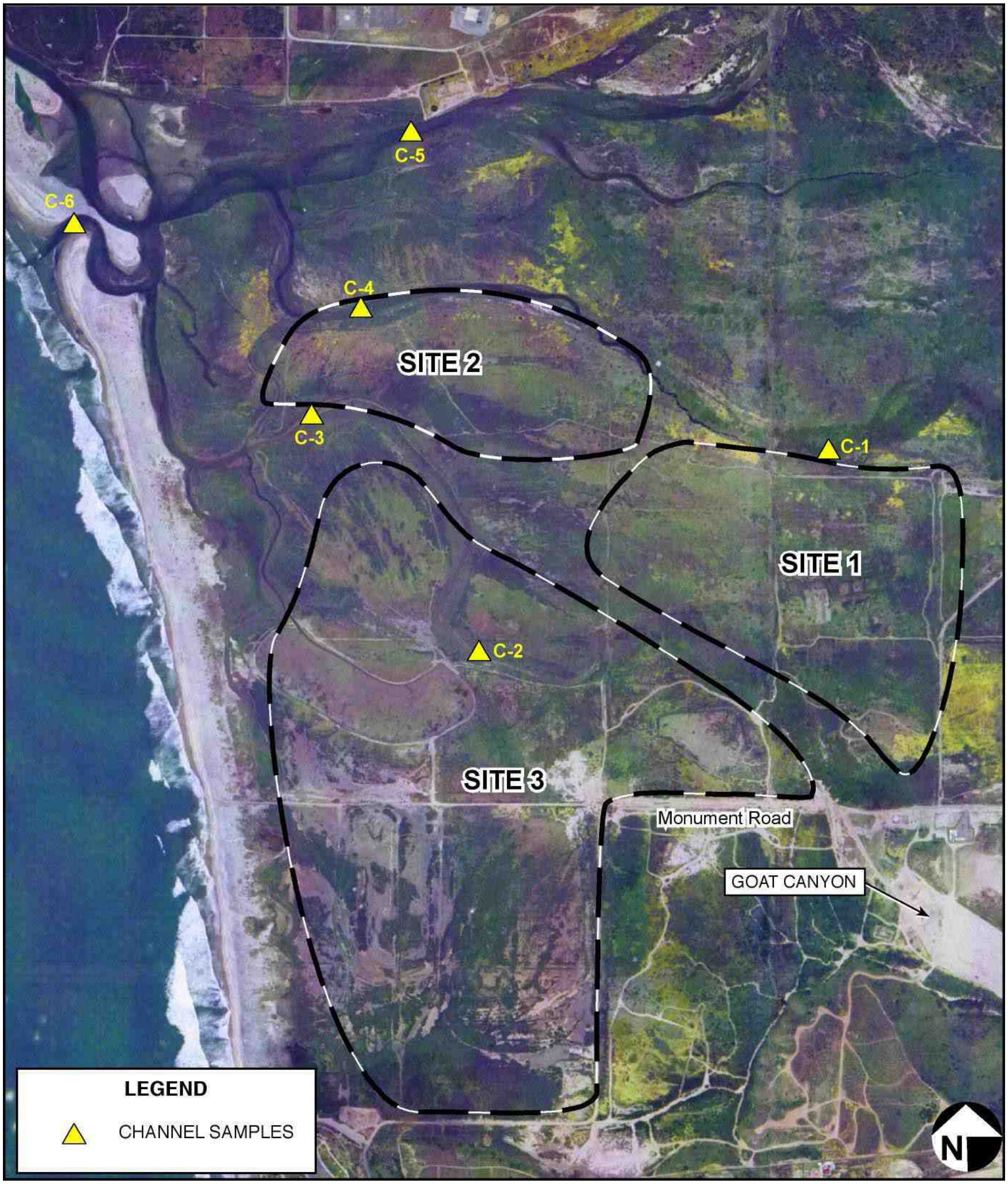


Figure 8-1. AMEC soil sampling plan

One core sample was collected at each of the 24 locations. Many of the sampling locations originally proposed in the SAP were moved either because they were not accessible or were in biologically sensitive areas. In areas accessible by vehicle, soil borings were collected with a CME 75 drill rig. In less accessible areas, a limited access rig (LAR) was used. An LAR is a smaller tracked vehicle capable of accessing wetter soils. In addition to soil borings, sediment samples were collected from the river channel at six locations to assist in hydrologic modeling (Figure 8-1). Collections for hydrologic modeling consisted of two-foot-deep core samples each of which was composited and analyzed for grain size only. All samples were collected between January 21 and February 2, 2004. The locations and sampling depth for all sediment collections are summarized in Table 8-1.

8.3.2 Core Logging and Sample Handling

For each sampling station, the station identification number, date, time of sampling, and GPS coordinates were recorded in a project-specific field log. Upon extrusion of the core, a description of the sediment (e.g., color, grain size, etc.), any odor, the core profile of the sample, and any other notable characteristics were recorded in the field log. A photo was also taken of each core referencing the sample's location number. The following information was recorded during the collection program in a project-specific field log:

- date and time of collection
- sample identification code
- sampling location (to within 3-meter accuracy)
- climatic conditions
- sampling method and any problems encountered
- sampler penetration (sample length)
- description of the material type obtained in the samples
- description of any vertical stratification in each core segment
- description of sediment subsampling methods
- photographic record
- additional comments

Additional details on sample handling are presented in Appendix E, Tijuana Estuary Feasibility Study Sediment Characterization Study Report (AMEC March 2005).

Grain Size Analyses

Grain size analyses were performed on individual strata following the EPA/USACE-approved sieve and hydrometer method (ASTM 1967). The results are reported in millimeters and phi sizes along with a cumulative grain size distribution graph.

Table 8-1. Core Sampling Locations (NAD83) and Target Penetration

Site	Location	Latitude	Longitude	Target Penetration (feet BGS)
1	1-1	32^o 33.0574	117^o 6.3605	20
	1-2	32^o 32.8873	117^o 6.3588	20
	1-3	32^o 33.0800	117^o 6.6118	20
	1-4	32^o 33.0973	117^o 6.7376	20
	1-5	32^o 32.9372	117^o 6.6069	20
	1-6	32^o 32.8248	117^o 6.6022	20
	1-7	32^o 32.9394	117^o 6.7324	20
2	2-1	32^o 33.1785	117^o 6.8568	20
	2-2	32^o 33.2564	117^o 7.0190	20
	2-3	32^o 33.1322	117^o 6.9639	20
	2-4	32^o 33.2462	117^o 7.1767	20
	2-5	32^o 33.2299	117^o 7.3273	20
3	3-1	32^o 33.0120	117^o 7.2103	20
	3-2	32^o 32.9170	117^o 7.3242	20
	3-3	32^o 32.8451	117^o 7.1764	20
	3-4	32^o 32.8648	117^o 6.9685	20
	3-5	32^o 32.7708	117^o 6.9317	20
	3-6	32^o 32.7813	117^o 6.7417	20
	3-7	32^o 32.6692	117^o 6.6904	20
	3-8	32^o 32.6214	117^o 7.0127	20
	3-9	32^o 32.4543	117^o 7.0147	20
	3-10	32^o 32.2811	117^o 7.0130	20
	3-11	32^o 32.2827	117^o 7.2103	20
	3-12	32^o 32.4704	117^o 7.3126	20
	3-13	32^o 32.6345	117^o 7.3142	20
Channel	C-1	32^o 33.0928	117^o 6.5223	2
	C-2	32^o 32.7941	117^o 7.0862	2
	C-3	32^o 33.1234	117^o 7.3477	2
	C-4	32^o 33.2821	117^o 7.2524	2
	C-5	32^o 33.5223	117^o 7.2225	2
	C-6	32^o 33.4031	117^o 7.7559	2

BGS - below ground surface

Chemical Analyses

Because the current study is a feasibility study, chemical analyses were conducted on a limited number of samples (n = 6); however, analyses were conducted on those samples that were determined to have the greatest potential for having detectable levels of contaminants. These included samples with a high percentage of fines in the upper surface layers. In addition, samples were selected to provide additional spatial information. The stations selected for chemical analyses include the top strata for Stations 1-2, 1-7, 2-3, and 2-4 (Figure 8-1). Composite samples were prepared from the top strata at stations 3-2, 3-3 and 3-4 (one sample) and 3-10, 3-11 and 3-13 (one sample). The samples were analyzed according to EPA/USACE-approved methods for the constituents listed in Table 8-2.

8.3.3 Results

For this report, silt and clay (fines) are defined as sediment with a grain size less than 75 microns (µm), while sand is defined as material greater than 75 µm. Sand is further delineated as fine sand (75 – 425 µm), medium sand (425 – 2,000 µm) and coarse sand (> 2,000 µm). Grain sizes for each sample are presented in Appendix D. Grain size results were compared with beach nourishment data from several studies conducted in the vicinity of the project.

Sediment chemistry is one of the primary factors used in determining potential disposal alternatives. However, there are no established federal or California sediment quality criteria for aquatic disposal. In lieu of established criteria, it is common to compare sediment chemical concentrations in test sediment to empirically derived data. While several sets of guidelines exist to assess the general sediment quality, the data set employed for this analysis to determine if the material is suitable for unconfined aquatic disposal is referred to as Effects Range – Low (ER-L) and Effects Range – Medium ER-M; (Long et al. 1995). These sediment quality guideline values are generally considered to be conservative estimates of sediment quality and are based on hundreds of empirically derived marine and estuarine field and laboratory tests.

The ER-L and ER-M sediment quality guidelines were derived by matching biological and chemical data from numerous studies. For this study, ER-L and ER-Ms were compared to nine metals, total polychlorinated biphenyl (PCBs), two pesticides (dichlorodiphenyl-dichloroethylene [DDE] and dichlorodiphenyl- trichloroehthane [DDT]), and 13 polycyclic aromatic hydrocarbon (PAHs). These chemicals would be expected from industrial contamination. Chemical concentrations below the ER-L rarely produce adverse effects. However, between ER-L and ER-M levels, effects may occasionally be observed. For the Bolsa Chica Wetlands Restoration Program, the California State Lands Commission determined that any material exceeding ER-L would be considered unsuitable for beach nourishment (California State Lands Commission 2001). However, the Bolsa Chica wetlands are perched over a significant oil deposit that has been extracted for many years leaving behind petroleum and other contaminants. The Tijuana Estuary sediments have been primarily influenced by agricultural and limited military presence. Thus, it is proposed that material with concentrations at or near ER-L be considered suitable for beach nourishment (nearshore placement).

Table 8-2. Chemical Analysis of Sediment/Soil Samples

Analytes	Preparation Method	Analysis Method	Sediment Target Detection Limits[a]
Total solids	-	160.3	0.1%
Total organic carbon	Acidify to release carbonates	9060	0.01%
Arsenic	3051[d]	6020[d]	0.1 (mg/kg)
Cadmium	3051[d]	6020[d]	0.1 (mg/kg)
Chromium	3051[d]	6020[d]	0.1 (mg/kg)
Copper	3051[d]	6020[d]	0.1 (mg/kg)
Lead	3051[d]	6020[d]	5.0 (mg/kg)
Mercury	Total digestion	7471A[d]	0.02 (mg/kg)
Nickel	3051[d]	6020[d]	0.1 (mg/kg)
Selenium	3051[d]	6020[d]	0.1 (mg/kg)
Silver	3051[d]	6020[d]	0.2 (mg/kg)
Zinc	3051[d]	6020[d]	2.0 (mg/kg)
TRPH	-	418.1M [d]	5.0 (mg/kg)
Chlorinated pesticides[f]	3550A[d]	8081A[d]	0.5 – 30 (μg/kg)
PCBs[g]	3550A[d]	8082[d]	20 (μg/kg)
Organophosphorous pesticides	3550A[d]	8082[d]	10 (μg/kg)
PAHs[e]	3550A[d]	8270C[d]	20 (μg/kg)
Phenols	3545[d]	8270C [d]	20 – 100 (μg/kg)
Phthalates	3545[d]	8270C [d]	10 (μg/kg)

[a] Sediment minimum detection limits are on a dry-weight basis.
[b] Reporting limits provided by Calscience Environmental Laboratories, Inc.
[c] Standard Methods for the Examination of Water and Wastewater, 19th Edition 1995.
[d] SW-846.
[e] Includes naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene), fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b,k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, benzo(g,h,i)perylene.
[f] Includes aldrin, α-BHC, β-BHC, γ-BHC (lindane), δ-BHC, chlordane, 2,4- and 4,4-DDD, 2,4- and 4,4-DDE, 2,4- and 4,4-DDT, dieldrin, endosulfan I and II, endosulfan sulfate, endrin, endrin aldehyde, heptachlor, heptachlor epoxide, and toxaphene.
[g] Includes Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, and 1262.
[h] (Rice, C.D. et al. 1987).

Acronyms:

PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
TRPH – total recoverable petroleum hydrocarbons
mg/kg – milligrams per kilogram (parts per million)
μg/kg – micrograms per kilogram (parts per billion)

Other sediment/soil guidelines considered for this analysis are primarily for potential upland reuse options. These include EPA preliminary remedial goals (PRGs), which are risk-based concentrations intended to assist in initial screening level evaluations or clean-up goals. In addition, the Regional Water Quality Control Board (RWQCB) requires a conditional waiver of waste discharge (i.e., Basin Plan) to determine the relative level of chemical contamination and potential impacts to any water body (i.e., surface water or ground water).

Quality assurance/quality control (QA/QC) was maintained during the analytical portion of this study by using duplicate sample analyses, reagent blanks, and spiked samples as specified in the EPA methods for individual analytes (Table 8-2). All QA/QC information is provided in the final testing reports (Appendix D).

8.3.4 Discussion of Methods

Grain Size

The results of the grain size analysis are summarized below and presented in Figures 8-2 through 8-4. Detailed analysis of each coring and the strata that comprise each boring are presented in Appendix D. Figures present sediment grain size distribution as probable (> 80% sand), possible (60 – 80% sand) and unlikely (< 60% sand). These categories are based on information available from studies conducted by the USACE for their proposed beach replenishment project at Imperial Beach (USACE 2002) and for the Port of San Diego Channel Deepening Project Port of San Diego, 2002). To summarize the results, the grain size distribution in the vicinity of Imperial Beach varied from approximately 96% sand and 4% fines on the beach to 80% sand and 20% fines in the nearshore, all of which were free of contaminants.

Site 1. Samples for Site 1 displayed a moderate amount of stratification, with two to four strata per core. The average grain size distribution indicated that 56% of the material was sand (48% fine sand, 7% medium sand and 1% coarse sand), while 44% of the material was silt and clay. The upper strata were generally composed of silt and clay (between 36% and 74%) and varied from the surface to a depth of 4.5 feet to 19 feet below ground surface (bgs; Figure 8-2). Sandy deposits, with greater than 70% sand, were present at all sampling locations, but varied with depth. Strata with a percentage of sand greater than 80% were present at six of the seven sampling locations, but again varied by depth, with most of these deposits situated at depths greater than 10 feet (Figure 8-2).

Site 2. Samples from Site 2 displayed far fewer strata, ranging from two to three strata per location (Figure 8-3). The average grain size distribution indicated that 81% of the material was sand (67% fine sand, 13% medium sand, and 1% coarse sand), while 19% was silt and clay. Material classified as either possible or probable was found at all strata at all sampling locations with the exception of sample 2-3 (Figure 8-3) suggesting that the sediments from this area are more compatible with the nearshore receiving site.

Site 3. Site 3 displayed a moderate amount of stratification, ranging from two to five strata per sampling location. The average grain size distribution of all the samples indicated that 56% of

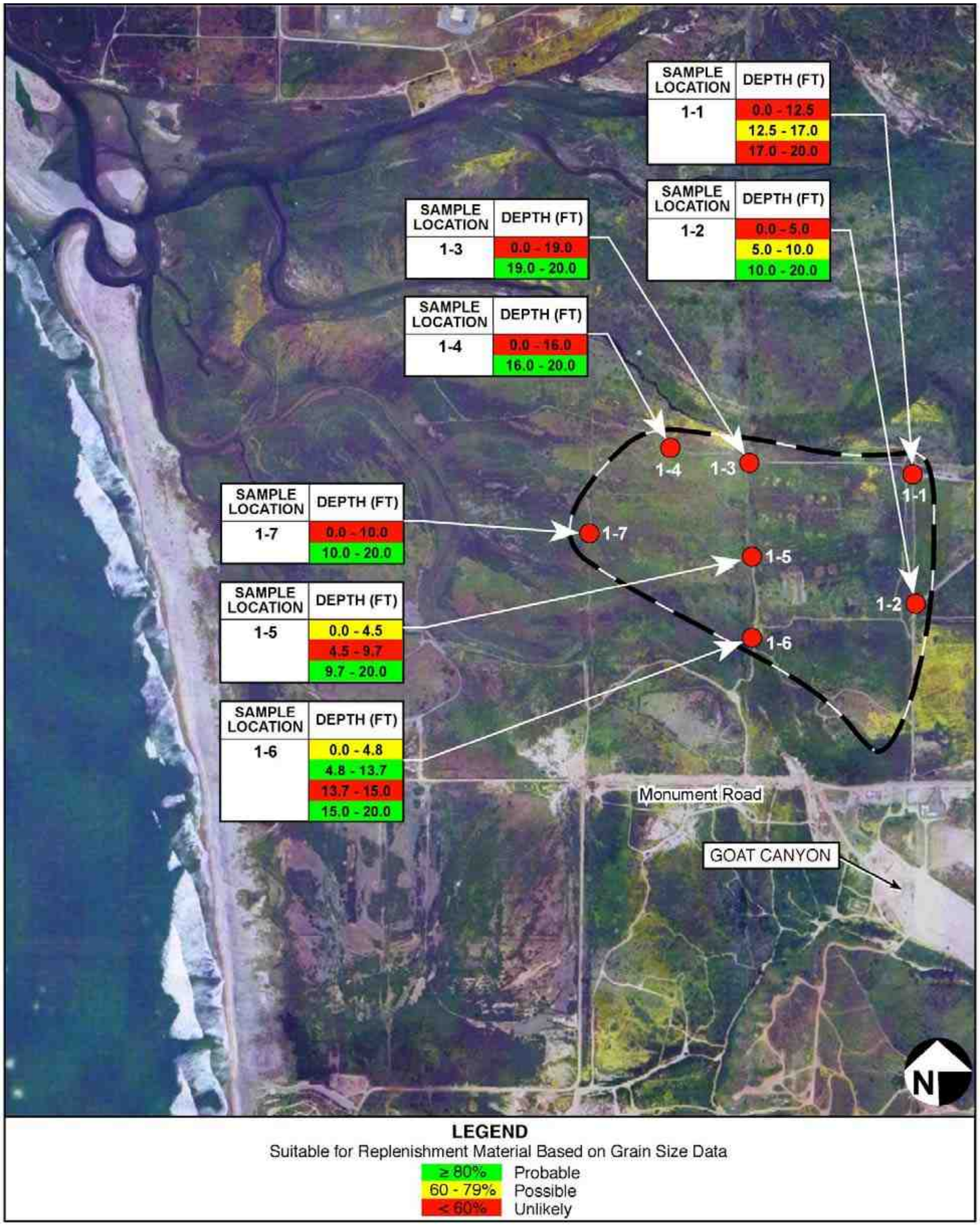


Figure 8-2. Grain Size Analysis Results for Site 1

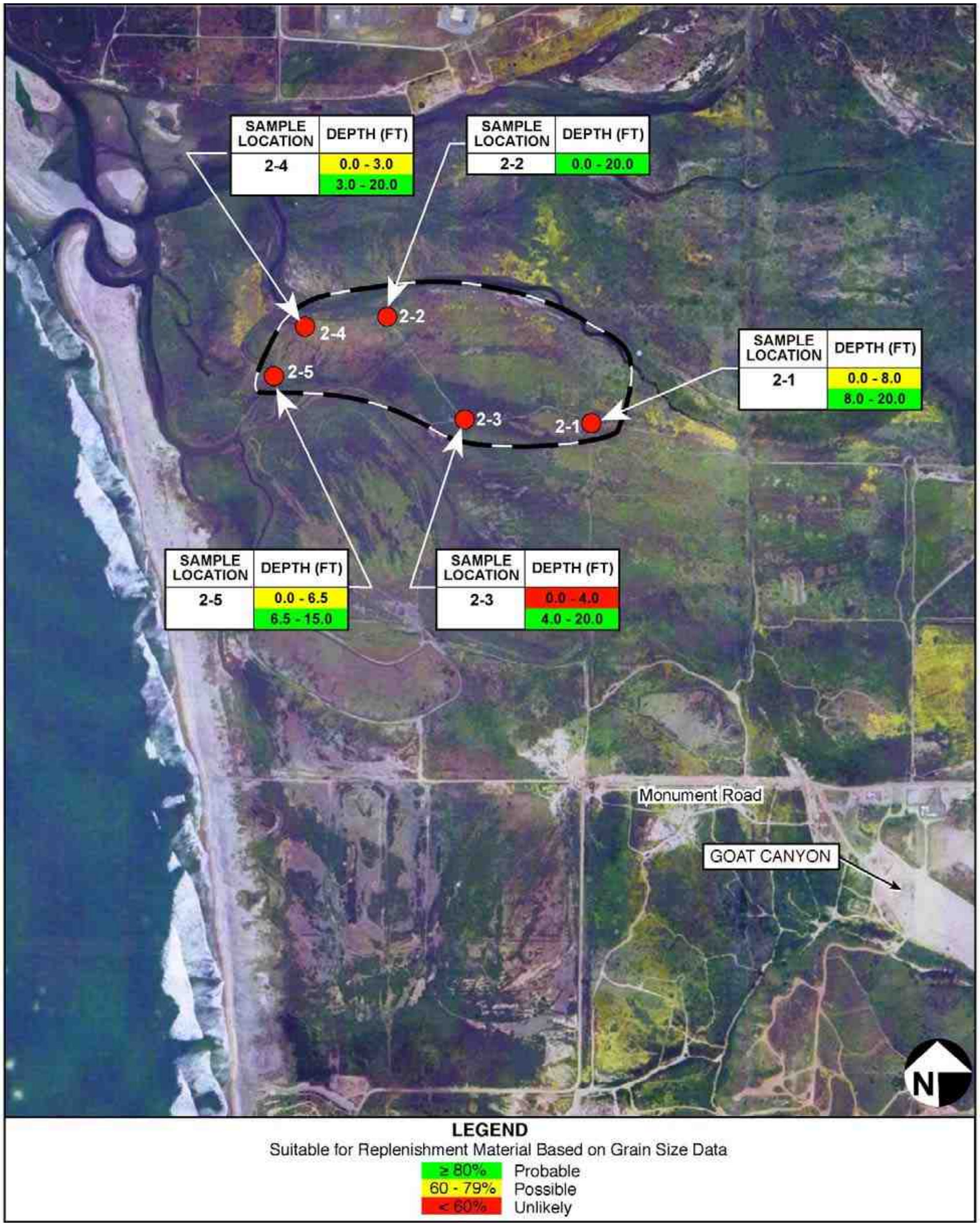


Figure 8-3. Grain Size Analysis Results for Site 2

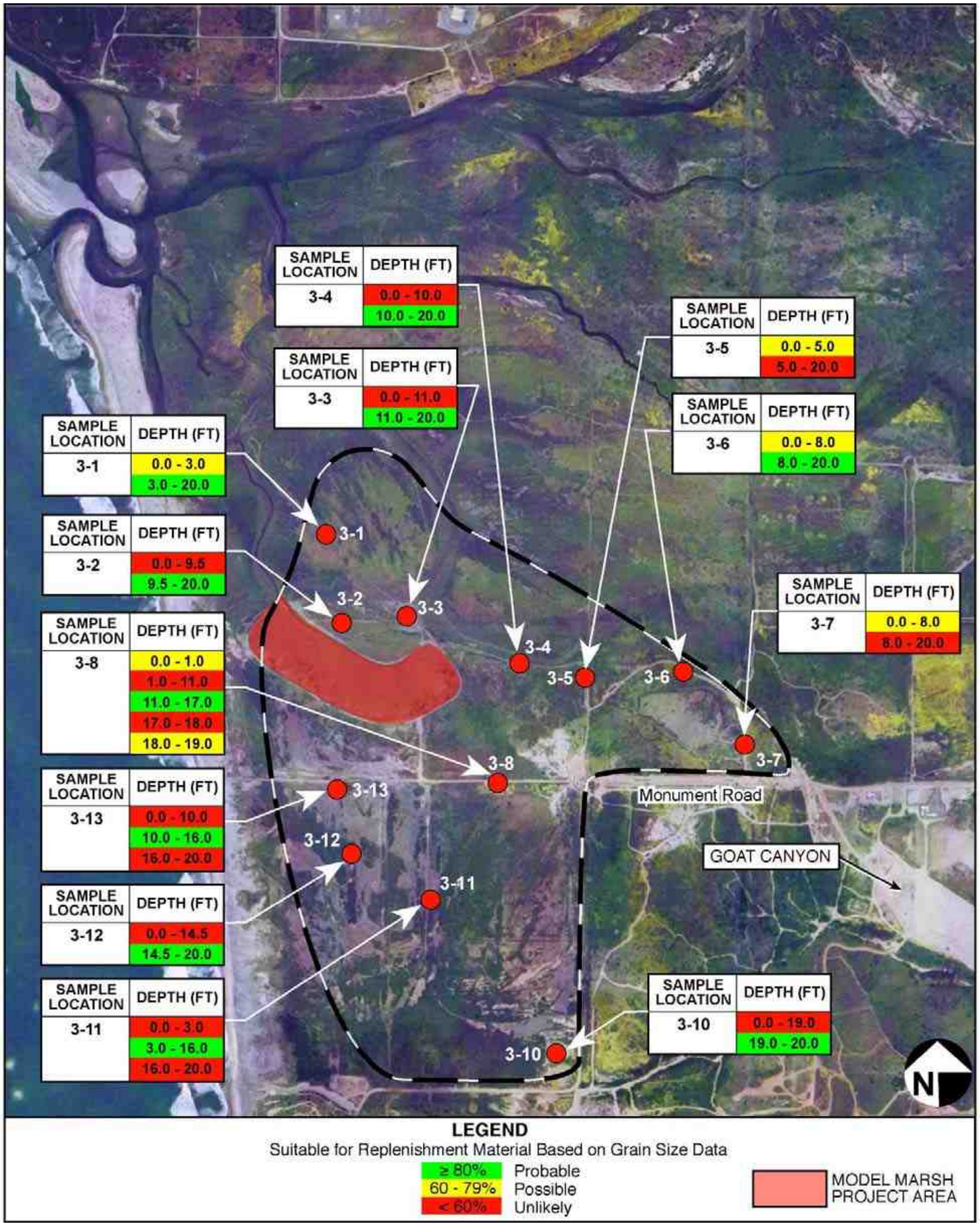


Figure 8-4. Grain Size Analysis Results for Site 3

the material was sand (48% fine sand, 7% medium sand, and 1% coarse sand), while 44% was silt and clay. Vertical distribution of suitable sands was highly variable, with a lens apparent below approximately 10 feet below ground surface (bgs**)** in sample locations 3-2, 3-3, 3-4, 3-6, 3-9, and 3-13; below 3 feet bgs at sample 3-1 and 3-11; and variable in other borings. These data suggest that areas north of the existing Model Marsh could be over excavated to find suitable sands for beach replenishment while most of the area south of the Model Marsh is too variable for such an operation (Figure 8-3).

Channel Samples. Sediment collected from estuarine channels located some distance away from the main channel (C-1, C-2 and C-3; Figure 8-1) were predominantly silt and clay (70% average) with some fine sand (30%). Station C-4, located near the terminus of the current channel of the Tijuana River, was predominantly sand 72%. The top 2 feet of sample C-5, located in the northern flow channel of the river, was 23% sand and 77% fines. From 2 feet bgs to 2.5 feet bgs, the material was 95% sand and 5% fines. Station C6, located near the tidal inlet, was 97% sand (96% of which was fine sand) with 3% fines.

Chemistry

For this report, the chlorinated pesticides DDT and its derivatives, DDE and dichlorodiphenyl-dichloroethane (DDD) are referred to as DDT through out the text. Bulk chemistry results and QA/QC information are presented in Appendix D.

Site 1. Chemical analyses were performed for the top strata from Stations 1-2 (0-5 feet bgs) and 1-7 (0-10 feet bgs). Analysis at Station 1-7 indicated that no significant metal or organic chemical contamination was present. The majority of the analyses results showed concentrations to be below detection limits. Phthalates were detected; however, they are common field and laboratory contaminants derived from the use of plastic materials. At Station 1-2, similar findings were observed with the exception of significant levels of DDTR (48 micrograms per kilogram) exceeding the ER-M of 46.1 micrograms per kilogram, but not exceeding the EPA PRGs for residential soils (1,700 micrograms per kilogram).

Site 2. Chemical analyses were performed for the top strata from Stations 2-3 (0-4 feet bgs) and 2-4 (0-3 feet bgs). These analyses indicated elevated levels of DDT, with a concentration at Station 2-3 (48 micrograms per kilogram) and at Station 2-4 (210 micrograms per kilogram), both of which exceed the ER-M of 46.1 micrograms per kilogram. Metals and other organic contaminant were observed at low concentrations or at concentrations below detection limits.

Site 3. Chemical analyses were performed for the top strata from Stations 3-2, 3-3, 3-4and 3-10, 3-11, 3-13. Slightly elevated DDT levels were observed for the composite sample at Stations 3-2, 3-3, 3-4 with a concentration of 2.6 micrograms per kilogram, which exceeds the ER-L of 1.58 micrograms per kilogram.

In order for the sediment of the project site to be suitable for beach disposal, the material must satisfy Clean Water Act §230.60(a), which, in part, states that the dredged or fill material will be free from chemical, biological, or other pollutants where it is composed primarily of sand, gravel, or other naturally occurring inert material. The criteria for suitable beach disposal include:

- Physically compatible material meeting Clean Water Act §230.60 criteria: or,
- Physically compatible material with contamination levels equal to or less than beach materials found at the nourishment sites; or,
- Physically compatible material that passes Tier II testing and does not exceed contamination levels acceptable for human exposure.

As presented previously, past studies indicate that the grain size distribution in the vicinity of Imperial Beach varied from approximately 96% sand and 4% fines on the beach to 80% sand and 20% fines in the nearshore, all of which was contaminant-free. Thus, the results of this preliminary analysis suggest that some strata are suitable for beach nourishment, but that those strata are not consistent across the project area. DDT and derivatives were detected in four of six composited surface samples, which would limit placement of these materials in the nearshore environment. It is not possible to delineate the extent or coverage of DDT and derivatives within the project area without additional chemical information from other sampling stations and strata. For those areas where total DDT concentrations exceed the ER-M (e.g., 1-2 and 2-4), it is unlikely that the material would be permitted for any in-water disposal scenario. Potential disposal options can include a variety of upland reuses, such as industrial fill or berm creation, as concentrations of other constituents were below criteria listed in the RWQCB Basin Plan – Report of Waste Discharge (RWQCB 1994). Samples where total DDT concentrations are at or below the ER-L may be permitted for nearshore disposal, assuming that the material meets the grain size criteria.

8.4 Supplemental Sediment Characterization

8.4.1 Methods

Additional data on sediment grain size distribution was collected in association with the trenching program designed to determine the potential for buried cultural resources (Section 9.0 Cultural Resources). Fifty trenches were excavated to varying depths using a backhoe in an attempt to determine the potential for buried cultural resources (Figure 8-5**.** Archaeological, biological and geological monitors were present during trenching to observe the presence of any buried cultural resources, to refine trench locations so as to avoid impacts to biological resources, and to observe and collect sediments for additional grain size analyses, respectively. A global positioning system (GPS) was used to locate the trenching locations and to record the actual sampling positions. Excavation was undertaken to the depth at which the rate of sidewall collapse approached the rate of excavation. During excavation, sediment type and the depth of strata boundaries were recorded. Depth was measured relative to the elevation at the site by using a weighted fiberglass tape that was deployed by hand. All samples were collected between 27 September and 4 October 2004. Table 8-3 summarizes information from the sampling effort.

Figure 8-5. Project Area Showing Individual Trench Locations

Table 8-3. Sampling Summary for the Tijuana Estuary Supplemental Grain Size Study

Trench Identifier	Date	Time	Latitude*		Longitude*		Maximum Depth (feet)
1	09/29/2004	1000	32°	32.640	117°	7.167	14
2	09/29/2004	1050	32°	32.637	117°	7.217	14
3	09/29/2004	1130	32°	32.636	117°	7.283	11
4	09/29/2004	1310	32°	32.639	117°	7.344	10
5	10/04/2004	1025	32°	32.694	117°	7.346	12
6	09/29/2004	1415	32°	32.580	117°	7.346	8
7	09/29/2004	1510	32°	32.546	117°	7.279	10
8	09/30/2004	900	32°	32.532	117°	7.218	14
9	09/30/2004	810	32°	32.535	117°	7.155	12
10	09/30/2004	1025	32°	32.478	117°	7.159	12
11	09/30/2004	1114	32°	32.420	117°	7.156	9
12	09/30/2004	1204	32°	32.418	117°	7.222	8
13	09/30/2004	1330	32°	32.356	117°	7.223	14
14	09/30/2004	1430	32°	32.416	117°	7.286	14
15	09/30/2004	1515	32°	32.419	117°	7.347	10
16	10/01/2004	835	32°	32.363	117°	7.343	6.5
17	10/01/2004	910	32°	32.362	117°	7.284	10
18	10/01/2004	1050	32°	32.850	117°	7.155	10
19	10/01/2004	1115	32°	32.903	117°	7.221	10.5
20	10/01/2004	1140	32°	32.996	117°	7.211	6.5
21	10/01/2004	1205	32°	33.019	117°	7.215	6
22	10/01/2004	1315	32°	32.972	117°	7.277	7.5
23	10/01/2004	1335	32°	32.962	117°	7.329	7.5
24	09/27/2004	1100	32°	32.872	117°	7.086	6
25	09/27/2004	1150	32°	32.874	117°	7.027	6
26	09/27/2004	1225	32°	32.862	117°	6.974	8
27	09/27/2004	1300	32°	32.867	117°	6.897	13.5
28	09/27/2004	1545	32°	32.707	117°	6.718	13
29	09/27/2004	1500	32°	32.882	117°	6.649	13
30	09/27/2004	1430	32°	32.766	117°	6.794	12.5
31	09/28/2004	815	32°	32.66	117°	7.073	14.5
32	09/28/2004	845	32°	32.657	117°	7.016	14.5
33	09/28/2004	910	32°	32.666	117°	6.953	14.5
34	09/28/2004	1020	32°	32.713	117°	6.951	14.5
35	09/28/2004	1100	32°	32.715	117°	7.018	13.5
36	09/28/2004	1130	32°	32.708	117°	7.082	13.5
37A	09/28/2004	1315	32°	32.595	117°	7.015	12
37B	10/01/2004	950	32°	32.594	117°	7.078	12.5
39	10/04/2004	800	32°	32.247	117°	6.907	15
40	09/28/2004	1445	32°	32.587	117°	6.946	11
41	09/28/2004	1410	32°	32.545	117°	6.951	10.5
42	09/28/2004	1400	32°	32.538	117°	7.012	9
43A	10/04/2004	1055	32°	32.558	117°	7.072	10.5
43B	10/04/2004	830	32°	32.201	117°	6.905	14
44	10/04/2004	855	32°	32.197	117°	6.962	14.5
45	10/01/2004	1420	32°	32.228	117°	7.273	14
46	10/01/2004	1445	32°	32.222	117°	7.343	8
49	10/04/2004	1200	32°	32.334	117°	6.949	14
50	10/04/2004	1400	32°	32.326	117°	7.004	13
51	10/04/2004	1430	32°	32.389	117°	6.949	12.5

* - Presented in NAD83 datum.

Trench Logging and Sample Handling

At each sampling location, the trench identification number, date, time of sampling, and GPS coordinates were recorded in a project-specific field log (log summaries are provided in Appendix E). A photograph was taken of each excavation, referencing the trench identifier (photographs are provided in Appendix E). In addition, the following information was recorded during the collection program:

- trench identification code
- sampling location
- date and time of collection
- problems encountered
- trench depth
- description of the material type obtained in the samples (e.g., color, grain size, odor, composite dimensions, depth of sample, etc.)
- description of vertical stratification in each stratum
- description of sediment sub-sampling methods
- depth and flow of groundwater
- presence of potential archaeological resources
- photographic record
- additional comments

Additional sampling methods and quality control protocols are presented in detail in Appendix E Tijuana Estuary Restoration Feasibility Study Supplemental Grain Size Report (AMEC, March 2005).

Grain Size Analyses

A total of 71 samples were collected; 58 of which were selected for grain size analysis. In selecting samples, priority was given to samples of strata exhibiting sandy characteristics. This was done to confirm results of visual/tactile assessments made in the field. Other samples were selected strategically to verify materials that were assessed in the field to have less than 80 percent sand. Grain size analyses were performed following the EPA/USACE-approved sieve and hydrometer method (ASTM 1967).

Data Analysis

For purposes of this study, silt and clay (fines) are defined as sediments with a grain size less than 63 microns (µm) (8.2) in diameter, while sand is defined as material retained on a 63 µm or greater sieve. The sand fraction was further delineated as fine sand (between 63 and 249 µm), medium sand (between 250 and 499 µm), and coarse sand (between 500 and 2,000 µm). Material retained on a 2,000 µm sieve was considered to be gravel.

8.4.2 Results

Table 8-4 provides a breakdown of the study results in terms of gravel, sand, silt and clay, as well as a breakdown of the distribution within each sand fraction. Grain size laboratory data summaries for each sample are in Appendix E.

In general, sediment grain size distributions fell into three categories: 1) those that contained beach replenishment-suitable material from the surface to the maximum depth; 2) those that contained suitable material at depth; and 3) those that contained no material suitable for beach replenishment at any depth. These results are presented graphically in Figures 8-6 and 8-7**.** The three categories are discussed below.

Type I – Beach Suitable Material

Trenches 19 through 23, located to the north of the Model Marsh, were found to generally exhibit beach-suitable grain size distributions (i.e., greater than 80 percent sand) from the surface to a maximum of 10.5 feet below ground surface (bgs). Exceptions to this generalization were the top 1 foot of material in Trench 22 (estimated to be sandy material, but with a slightly greater fraction of fines) and material from 6 to 9 feet in Trench 19 (estimated to contain less than 60 percent sand).

Type II – Beach Suitable Material at Depth

This type of material consists of sandy material at depth, overlain by sediments with large proportions of silts and clays. This was generally the case for trenches in the following areas:

- To the northeast of the Model Marsh (Trenches 18 and 24 through 30); the top of the sandy strata was observed from as shallow as 1.5 feet bgs (Trench 24) to as deep as 12.5 feet bgs (Trench 27).
- Trenches 4 through 7 to the south of the Model Marsh in the vicinity of the tidal channel on the east side of the coastal dune system (Figure 1); sandy material was observed from approximately 6 feet bgs to at least 10 feet bgs.
- Trenches 10 through 12; sandy material was observed below approximately 3 feet bgs to the bottom of the trenches, which ranged from 8 to 12 feet bgs.
- Trenches 45 and 46 just north of Border Field, which exhibited sands from 2.5 to 14 feet bgs in Trench 45 and 6 to 8 feet (the maximum depth) in Trench 46.
- Trenches 49 through 51, which exhibited sandy material from approximately 11 to 12 feet bgs to maximum trench depth (12.5 to 14 feet bgs).

Table 8-4. Summary of Grain Size Distribution Data Including Approximate Sample Depth

		Sample Locations									
Size Fraction	Size (µm)	TE 1T	TE 1B	TE 2B	TE 3B	TE 4B	TE 5B	TE 6B	TE 7B	TE 8B	TE 9B
% Gravel	> 2000 µm	0.0%	0.0%	0.0%	0.2%	0.1%	0.1%	3.0%	0.0%	0.8%	0.0%
% Sand	> 63 µm	47.6%	38.7%	54.3%	63.8%	91.2%	83.2%	72.3%	86.1%	76.8%	18.7%
% Silt	> 2 µm	44.9%	58.8%	43.0%	32.3%	6.2%	14.1%	21.0%	8.1%	18.7%	68.4%
% Clay	< 2 µm	7.5%	2.6%	2.6%	3.7%	2.5%	2.6%	3.7%	5.8%	3.7%	13.0%
% Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
% Sand (coarse)	500-2000 µm	1.7%	1.0%	1.2%	0.9%	1.3%	1.9%	17.0%	37.2%	1.4%	0.7%
% Sand (med)	250-499 µm	3.1%	9.4%	3.6%	11.5%	23.7%	22.4%	33.3%	40.3%	18.6%	2.6%
% Sand (fine)	63-249 µm	42.8%	28.3%	49.5%	51.4%	66.3%	59.0%	22.0%	8.5%	56.8%	15.4%
% Fines (Silt+Clay)	< 63 µm	52.40%	61.35%	45.65%	36.01%	8.67%	16.72%	24.70%	13.90%	22.42%	81.32%
Sample depth (ft)		0.75'-5.5'	11'-14'	10.5'-14'	10.5'	6'-10'	6.5'-12'	5.5'-8'	8.5'	13.5'	9'-12'

		Sample Locations									
Size Fraction	Size (µm)	TE 10M	TE 10B	TE 11M	TE 12M	TE 13T	TE 13M	TE 14T	TE 15B	TE 16M	TE 17B
% Gravel	> 2000 µm	4.8%	0.1%	0.0%	1.2%	0.7%	0.4%	0.3%	0.0%	0.0%	0.0%
% Sand	> 63 µm	86.2%	88.0%	94.0%	95.6%	82.3%	12.9%	84.6%	93.9%	78.8%	92.3%
% Silt	> 2 µm	5.1%	7.1%	2.4%	1.1%	12.5%	61.7%	10.4%	3.6%	16.5%	3.8%
% Clay	< 2 µm	3.9%	4.8%	3.6%	2.1%	4.5%	24.9%	4.6%	2.4%	4.7%	3.8%
% Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
% Sand (coarse)	500-2000 µm	25.9%	8.3%	28.1%	38.4%	5.7%	1.9%	7.8%	3.2%	3.0%	4.4%
% Sand (med)	250-499 µm	33.7%	42.5%	56.0%	46.4%	22.5%	3.2%	27.0%	53.1%	36.0%	36.0%
% Sand (fine)	63-249 µm	26.7%	37.2%	9.9%	10.9%	54.1%	7.7%	49.8%	37.6%	39.9%	51.9%
% Fines (Silt+Clay)	< 63 µm	9.0%	11.9%	6.0%	3.2%	17.0%	86.7%	15.1%	6.1%	21.2%	7.7%
Sample depth (ft)		5'	10'	8'	5'	2'-4'	4'-6.5'	1'-3'	10'	1.5'-5'	5.5'-10'

Table 8-4. Continued

		Sample Locations									
Size Fraction	Size (µm)	TE 18B	TE 19M	TE 20M	TE 21B	TE 22M	TE 23B	TE 24M	TE 24B	TE 25M	TE 25B
% Gravel	> 2000 µm	0.0%	0.5%	2.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.2%	0.3%
% Sand	> 63 µm	92.9%	89.0%	94.4%	92.4%	90.6%	88.2%	96.8%	96.2%	32.7%	90.8%
% Silt	> 2 µm	7.1%	9.1%	1.2%	5.0%	6.7%	9.2%	2.1%	1.3%	58.2%	5.9%
% Clay	< 2 µm	0.0%	1.3%	2.4%	2.5%	2.7%	2.6%	1.1%	2.5%	9.0%	3.0%
% Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
% Sand (coarse)	500-2000 µm	5.4%	12.5%	47.3%	9.4%	5.5%	0.4%	7.1%	9.1%	6.8%	10.8%
% Sand (med)	250-499 µm	36.8%	33.4%	34.8%	28.9%	32.0%	1.3%	50.4%	56.4%	4.9%	50.0%
% Sand (fine)	63-249 µm	50.7%	43.2%	12.3%	54.1%	53.1%	86.4%	39.4%	30.7%	20.9%	30.0%
% Fines (Silt+Clay)	< 63 µm	7.1%	10.4%	3.6%	7.5%	9.4%	11.8%	3.2%	3.8%	67.2%	8.9%
Sample depth (ft)		8.5'-10'	9'-10.5'	6'-6.5'	5.5'-6'	4'-7.5'	4'-7.5'	1.5'-6'	6'	5'-5.5'	7'

		Sample Locations									
Size Fraction	Size (µm)	TE 26B	TE 27B	TE 28M	TE 28VB	TE 29B	TE 30B	TE 31B	TE 32B	TE 33B	TE 34B
% Gravel	> 2000 µm	2.7%	1.8%	0.1%	0.6%	0.9%	2.8%	0.1%	0.1%	0.1%	0.1%
% Sand	> 63 µm	94.9%	91.9%	88.3%	94.4%	87.9%	89.0%	89.8%	42.7%	62.9%	63.0%
% Silt	> 2 µm	2.4%	5.1%	9.1%	2.5%	7.0%	7.1%	10.1%	55.9%	35.7%	34.3%
% Clay	< 2 µm	0.0%	1.3%	2.6%	2.5%	4.2%	1.2%	0.0%	1.3%	1.3%	2.5%
% Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
% Sand (coarse)	500-2000 µm	38.0%	22.5%	0.3%	40.7%	9.8%	9.0%	3.4%	0.4%	2.5%	2.9%
% Sand (med)	250-499 µm	40.4%	39.3%	29.2%	37.3%	38.4%	53.1%	29.7%	1.3%	5.7%	7.2%
% Sand (fine)	63-249 µm	16.5%	30.0%	58.7%	16.4%	39.6%	26.8%	56.6%	41.1%	54.7%	52.9%
% Fines (Silt+Clay)	< 63 µm	2.4%	6.3%	11.7%	5.0%	11.2%	8.2%	10.1%	57.2%	37.0%	36.8%
Sample depth (ft)		4.5'-8'	13.5'	6'-9.5'	13'	12'-13'	12.5'	12.5'-14.5'	10'-14.5'	12.5'-14.5'	11'-14.5'

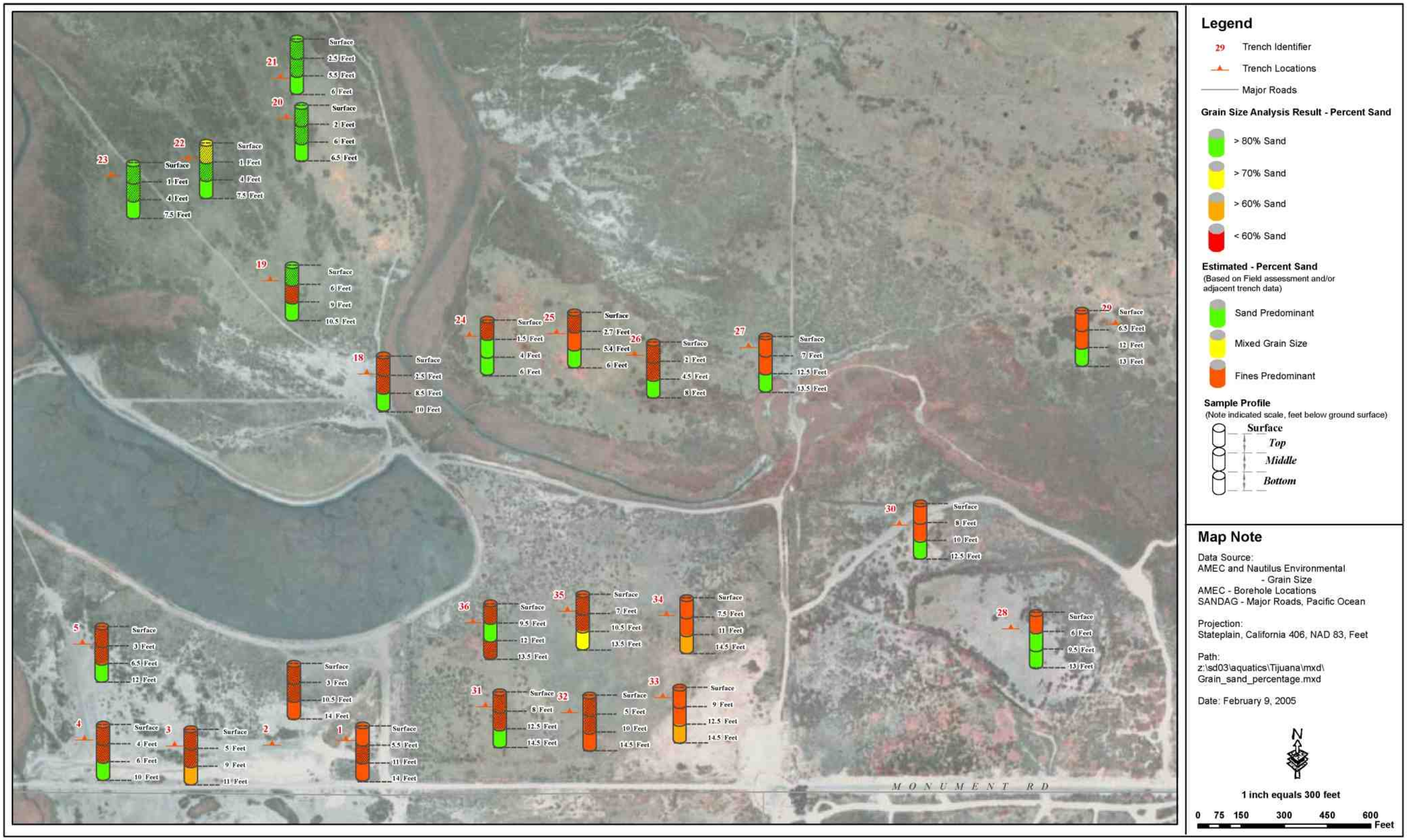
Table 8-4. Continued

		Sample Locations								
Size Fraction	Size (µm)	TE 35B	TE 36M	TE 37AB	TE 37BT	TE 37BB	TE 40M	TE 40B	TE 41C	TE 42M
% Gravel	> 2000 µm	1.8%	0.4%	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
% Sand	> 63 µm	70.6%	93.5%	95.0%	55.1%	44.1%	93.6%	97.3%	92.3%	98.8%
% Silt	> 2 µm	24.9%	4.9%	2.6%	42.2%	53.2%	6.4%	1.4%	6.4%	0.0%
% Clay	< 2 µm	2.6%	1.2%	1.3%	2.6%	2.7%	0.0%	1.4%	1.3%	1.2%
% Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
% Sand (coarse)	500-2000 µm	7.0%	10.5%	41.1%	0.8%	3.2%	3.3%	5.5%	4.3%	7.9%
% Sand (med)	250-499 µm	26.0%	30.2%	37.1%	3.2%	3.5%	28.3%	33.9%	30.0%	73.8%
% Sand (fine)	63-249 µm	37.7%	52.8%	16.8%	51.1%	37.4%	62.0%	57.8%	58.0%	17.1%
% Fines (Silt+Clay)	< 63 µm	27.5%	6.1%	3.9%	44.9%	55.9%	6.4%	2.7%	7.7%	1.2%
Sample depth (ft)		13'	12'	7'-12'	3'-5'	10'-12.5'	5'-7.5'	7.5'-11'	4'-10.5'	6.5'

		Sample Locations								
Size Fraction	Size (µm)	TE 43BB	TE 43AB	TE 43AM	TE 44B	TE 45M	TE 49B	TE 46M	TE 50B	TE 51B
% Gravel	> 2000 µm	0.0%	0.1%	0.0%	0.0%	0.0%	0.6%	0.0%	0.0%	0.0%
% Sand	> 63 µm	8.3%	96.3%	95.2%	69.3%	97.5%	85.8%	98.7%	84.0%	91.4%
% Silt	> 2 µm	79.0%	2.4%	3.6%	26.7%	1.3%	12.2%	0.0%	14.7%	6.8%
% Clay	< 2 µm	12.7%	1.2%	1.2%	4.0%	1.3%	1.4%	1.3%	1.3%	1.7%
% Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
% Sand (coarse)	500-2000 µm	2.0%	4.8%	36.8%	1.7%	2.9%	5.6%	4.2%	1.9%	1.0%
% Sand (med)	250-499 µm	1.8%	65.8%	44.6%	11.6%	47.4%	15.5%	59.6%	12.8%	8.0%
% Sand (fine)	63-249 µm	4.4%	25.8%	13.8%	55.9%	47.2%	64.7%	34.9%	69.2%	82.4%
% Fines (Silt+Clay)	< 63 µm	91.7%	3.6%	4.8%	30.7%	2.5%	13.5%	1.3%	16.0%	8.6%
Sample depth (ft)		4.5'-7'	7'-10.5'	3'-5'	14'-14.5'	8'-14'	12'-14'	6'-8'	11'-13'	12'-12.5'

Greater than 80 percent sand. (green)

Greater than 30 percent fines. (red)



amec

FIGURE 8-6 Grain Size Sand Percentages, Northern Trench Locations

Legend

29 Trench Identifier

Trench Locations

Major Roads

Grain Size Analysis Result - Percent Sand

> 80% Sand

> 70% Sand

> 60% Sand

< 60% Sand

Estimated - Percent Sand
(Based on Field assessment and/or adjacent trench data)

Sand Predominant

Mixed Grain Size

Fines Predominant

Sample Profile
(Note indicated scale, feet below ground surface)

Surface
Top
Middle
Bottom

Map Note

Data Source:
AMEC and Nautilus Environmental
- Grain Size
AMEC - Borehole Locations
SANDAG - Major Roads, Pacific Ocean

Projection:
Stateplain, California 406, NAD 83, Feet

Path:
z:\sd03\aquatics\Tijuana\mxd\
Grain_sand_percentage.mxd

Date: February 9, 2005

N

1 inch equals 300 feet

0 75 150 300 450 600 Feet

FIGURE 8-7 **Grain Size Sand Percentages, Southern Trench Locations**

Type III – Unsuitable Material

This type of material consisted of sediments which were unsuitable for beach placement (i.e., less than 60 percent sand) throughout the area sampled, or consisted of sediments that contained sand at depth which was less than optimal (between 60 and 71 percent sand). This was the case for the following areas:

- Trenches 1 through 3 to the south of the Model Marsh contained sand fractions ranging from 38.7 to 63.8 percent in the bottom strata, which ranged in depth from between 9 and 11 feet bgs to a maximum depth of 11 to 14 feet bgs.
- Trenches 8, 9, and 37 to the southeast of the Model Marsh contained a small quantity of sand, particularly for the bottom stratum of Trench 9 (18.67 percent). Adjacent trenches to both of these locations, however, exhibited sand in quantities sufficient for use as beach nourishment. (Note: the Trench 8 bottom sample was collected from an apparent vein of sand and is represented as >80 percent sand in Figure 8-6. The core log, however, indicates the predominance of fines in the lower portion at that location).
- Trenches 32 through 35 to the southeast of the Model Marsh contained sand proportions ranging from 42.7 percent to 70.6 percent from an upper depth ranging from 10.5 to 12.5 feet bgs to the maximum trench depth (which ranged from 13.5 to 14.5 feet bgs).
- Trenches 39 and 43B in the southeast portion of the project area contained silty and/or clayey sediments throughout the entire depth sampled. Neighboring Trench 44 (the only sampling location in the immediate vicinity) had 69.3 percent sand from 14 to 14.5 feet bgs.

8.4.3 Discussion – Supplemental Sediment Characterization

Aquatic Disposal Requirements

As presented previously, the grain size distribution in the vicinity of Imperial Beach varied from approximately 96 percent sand and 4 percent fines on the beach, to 80 percent sand and 20 percent fines in the nearshore environment. Chemical analysis of the receiver sites found the site to be substantially free of contamination. Based on these compatibility criteria, it is possible to determine the potential suitability of the material from the Tijuana Estuary for beach nourishment, under the assumption that the results from chemical tests indicate no contaminants of concern. Four categories were created to determine the potential suitability of the material based on grain size distribution: 1) likely - greater than 80 percent sand; 2) probable - between 70 and 79 percent sand; 3) possible - between 60 and 69 percent sand; and 4) unlikely - less then 60 percent sand.

Figures 8-5 and 8-6 show the strata at each sampling location that fit these categories. For all samples, the higher the percentage of sand, the greater the likelihood that the material could be placed directly on the beach. If the grain size distribution is greater than 80 percent sand, it is likely that the material would be suitable for either onshore or nearshore placement. If the material is between 60 percent and 79 percent sand, it may be less likely to be permitted for direct placement on the beach, although it may be suitable for nearshore placement. Material with less than 60 percent sand is unlikely to be suitable for nearshore placement, although other reuse options such as berm creation or fill could be considered.

Some material strata deemed unsuitable for beach or nearshore replenishment may become suitable when they occur in mixed layers with suitable materials. For example, if a thin layer of fine material (e.g., 60 percent sand) is composited with a thick layer of high percentage sand (e.g., 95 percent sand), the average grain size distribution may indicate that the composite would be suitable for beach nourishment (e.g., 85 percent sand). In another recent restoration example, there were samples from the POSD Channel Deepening Project with 64 percent sand, but when composited with material from the other locations, the average of all the samples was 83 percent sand, which was permitted for nearshore placement (POSD 2002).

Comparison with AMEC 2004 Data

The results obtained in the current study were compared to the grain size data obtained from the previous sediment characterization (AMEC 2004) to determine the level of data compatibility. This assessment was only possible for the depth sampled during this event, which was universally shallower than that achieved during the previous event. The 2004 effort utilized a drill rig that was able to penetrate to 20 feet bgs at all stations whereas the maximum depth achieved during the current effort was 15 feet bgs and averaged 11.5 feet bgs. The limited depth achieved in this study was primarily due to intrusion of groundwater in the trenches that in turn caused sidewall collapse.

Despite the limitations of the most recent assessment, the results of the two efforts were similar. Both studies indicate that the area north of the Model Marsh is particularly suitable for excavation and/or dredging due to the high sand content. Results of this study indicate that much of the area south of the Model Marsh consists of sandy lenses below surface layers with grain size distributions unsuitable for beach replenishment (i.e., Type II from above). While this is in agreement with the previous results, the 2004 data also indicates that material below the maximum depth of the trenches consists of materials unsuitable for beach and/or nearshore disposal.

The 2004 data provides additional context to the current data for two cases in particular: 1) in the vicinity of the tidal channel, inshore of the dune system, and to the south of the Model Marsh. 2) in the southernmost portion of the project area.

Sample Location 3-12 exhibited sandy material from 14.5 feet to 20 feet bgs (86 percent) (AMEC 2004). Data for Trenches 4 through 7 averaged 82.3 percent sand in the bottom strata, but for a depth horizon from 6 to 10 feet bgs. Confirmation studies using drill rig techniques may be useful in further defining the extent of sandy material at depth in this area. Transporting sandy material to the nearby beach during restoration would cost less per unit for this area than other areas farther away from the beach and the area is therefore an attractive restoration site. Obtaining additional stratigraphic data along the back dune at depths greater than 15 feet bgs may be particularly worthwhile.

Sample location 3-10 was in the vicinity of trenches 39, 43B, and 44 that indicated a lack of sandy material. However, a limited amount of sandy material was observed in the very bottom of the single core sample collected in the area (85 percent sand from 19 to 20 feet bgs). The sandy material may be more widespread at depths below the maximum trench depths (approximately 15 feet bgs), however, utilizing sand from this location would require upland disposal of large volumes of overlying fine sediments.

9.0 CULTURAL RESOURCES

The following cultural resources analysis was prepared by Tierra Environmental Services and is presented here in its entirety.

9.1 Natural Setting

Native Americans focused their way of life toward the natural world and because of this an understanding of the natural setting is critical to interpreting the cultural resources in the project vicinity. While the estuary and open beach at the mouth of the estuary offer a variety of marine resources, potential resource diversity was provided by rocky shore habitats to the southwest of the area along Playas de Tijuana. Riparian habitats along the Tijuana River offered additional resources. Major environmental factors such as geology, hydrology, climate, vegetation, and animal resources provided the setting for the inhabitants of the lower Tijuana River Valley and each of these aspects are discussed in greater detail below.

Geology and Hydrology

Much of the following is derived from Kennedy and Tan's report on the geology of southwest San Diego County prepared for the California Division of Mines and Geology (1977). The landscape of the project area as a whole is largely a product of the region's geology. The San Diego area coastal plain consists primarily of Eocene deltaic sediments shaped by Pleistocene marine terraces and Holocene erosion. The Eocene sediments from the Poway Group of formations were deposited as part of a series of large river deltas along a coastline where sea level rose and fell dramatically. The rivers originated as far east as Sonora, Mexico and transported well-rounded porphyritic volcanic and quartzite cobbles to the San Diego region. These cobbles were deposited in conglomerate formations and smaller lenses within Eocene sediments and later provided Native Americans in the region with a source of material for flaked stone tools. Eocene age formations are not located in the immediate vicinity of the project but occur to the east underlying portions of the Otay Mesa region.

The Pliocene brought a rise in sea level and much of the western San Diego urban area was part of a large embayment. The San Diego Formation which includes many reworked cobbles from the Eocene sediments along with a diverse marine fossil assemblage was deposited during this period. This formation is present to the south and southeast of the project area (Kennedy and Tan 1977).

During the Pleistocene, sea levels again rose. The coastal plain was submerged and flattened into large mesa areas by wave action. The Linda Vista Formation was deposited as a cap on the mesas in this shallow marine environment. As the sea level fluctuated and dropped, the Pleistocene Bay Point Formation was left behind the Nestor Terrace below the higher Linda Vista terrace along the coastline. This formation includes some reworked cobbles from the older Eocene formations and underlays much of the area to the north of Tijuana River Valley (Kennedy and Tan 1977).

The Tijuana River created the Tijuana River Valley by eroding through uplifted sedimentary formations. Holocene changes in sea level later resulted in the creation of a bay at the mouth of the river when rising ocean water filled the mouth of the river valley. With a slowing of sea level rise, river sediments have filled the lower portion of the valley and much of the embayment creating the flood plain and estuary that exists today. The Model Marsh is located on this Holocene age alluvium at the margin of the estuary.

Other formations east of the project area include volcanic and granitic rocks of the foothills and peninsular ranges. The San Diego region was near a tectonic plate boundary in the Mesozoic era, and marine sediments were intruded by a volcanic island arc system. These volcanic rocks (Santiago Peak Volcanics) were later metamorphosed and became an important source of tool material for Native American flaked tool production. Plutonic intrusive rocks (batholithic) also formed along this belt near the end of the Mesozoic era. These rocks were later uplifted during periods of mountain building and now form the majority of the peninsular ranges. Santiago Peak Volcanics do not outcrop within the project area, but the lithic material can be found as clasts within Tijuana River sediments. Batholithic rocks outcrop farther to the east of the project and were often used by Native Americans for grinding tools and surfaces.

Today the Holocene sediments of the alluvial Tijuana River flood plain extend approximately 1 to 2 miles north/south and 7 miles east/west. The Imperial Beach area on the northern side of the river valley consists of a higher area underlain by the Bay Point Formation and an unnamed sandstone formation (Kennedy and Tan 1977). These two formations were not differentiated in the geologic mapping of the area and are both discussed below.

The Bay Point Formation is well exposed in much of the area surrounding San Diego Bay. The formation is made up of marine, lagoonal, and non-marine poorly consolidated sandstone. The Bay Point Formation was laid down on the marine cut Nestor Terrace during the late Pleistocene, Sangamon interglacial high sea stand dating to 120,000±10,000 years ago (Kennedy and Tan 1977). The unnamed marine sandstone is made up of nearshore marine sediments similar to the Bay Point Formation in color and texture and the two formations are indistinguishable in many areas. They are separated by a low relief unconformity that is nearly planar (Kennedy and Tan 1977). Both of these formations contain little in the way of lithic material that could be used for stone tool production. Some reworked Eocene age volcanic cobbles and cobbles from the Santiago Peak Volcanic Formation to the east are exposed in cuts within the Imperial Beach area however. Cherts, probably derived from the Otay Formation to the east, have also been noted as rare beach cobbles in the Imperial Beach area.

The southern side of the Tijuana River Valley includes a greater range of uplifted sedimentary formations than the relatively low topography of the Imperial Beach area. Spooner's Mesa and the adjacent mesas along the International Border reach elevations of 379 feet while the flood plain below is approximately 25 feet above mean sea level (AMSL). Lower mesas south of the project area are flattened by Pleistocene wave action associated with the Nestor Terrace and are capped by the Bay Point Formation. This area and much of Spooner's Mesa is underlain by the Pliocene age San Diego Formation (Kennedy and Tan 1977). In this area the San Diego Formation has been divided into two parts; a conglomerate and a sandstone. The conglomerate part is pebble, cobble, and boulder conglomerate that is poorly sorted, well indurated, and cemented with ferruginous cement. The composition of the clasts is extremely varied. Metavolcanic cobbles typical of nearby Eocene formations constitute approximately 75 percent of the unit. Other materials include granitic and metamorphic rocks from the peninsular range to the east. The formation is typically reddish brown resulting from the iron cement. This portion of the San Diego Formation is highly resistant to weathering and forms steep slopes and cliffs (Kennedy and Tan 1977).

The sandstone part of the San Diego Formation is marine and fine grained. It lies generally below and east of the conglomerate part. The sandstone is typically yellowish brown, poorly indurated, and locally cemented with limey cement (Kennedy and Tan 1977).

The upper part of Spooner's Mesa and the high mesa to the east are capped by the Linda Vista Formation (Kennedy and Tan 1977). The Linda Vista Formation consists of nearshore marine and nonmarine sediments that were deposited on the wave cut Linda Vista Terrace. This terrace was approximately 10 kilometers wide and was deposited during the early Pleistocene. The deposits are composed of moderate reddish brown interbedded sandstone and conglomerate. Ferruginous cement gives this formation its characteristic reddish-brown color and resistant nature (Kennedy and Tan 1977).

The elevation of the project area ranges from approximately sea level in some of the connecting channels to about five feet above mean sea level. The area rises to the southeast where it is influenced by part of an alluvial fan associated with Goat Canyon. A tidal marsh is the most prominent feature of the project area, although reduced in size from a variety of disturbances. A series of dunes paralleling the coast are present to the west of the project area along the current beach line. The project is mapped as Holocene age alluvium (Kennedy and Tan 1977) and soils are described as tidal flats (USDA 1973).

The Tijuana River which defines the northern limit of the project area, is a major drainage in the southern California region. It drains an area of more than 448.323 hectares (ha), three fourths of which lies in Mexico (Zedler et al. 1992). The river's flows are highly variable ranging from extreme floods to very limited flows. Goat Canyon and Smuggles Gulch are important seasonal tributaries to the Tijuana River in the vicinity of the project. The river channel has shifted on its delta in the Tijuana River valley over time. Not only would the river have provided a potential source of fresh water to the ancient inhabitants of the area but the drainage system with its large watershed culminating in the Tijuana River Valley would have provided an access corridor to interior areas and resources ranging from interim habitation sites to upland resources.

9.2 Cultural Setting

Paleoindian Period

The earliest well documented prehistoric sites in southern California are identified as belonging to the Paleoindian period, which has locally been termed the San Dieguito complex/tradition. The Paleoindian period is thought to have occurred between 8000 and 9,000 years ago in this region. Although varying from the well-defined fluted point complexes such as clovis, the San Dieguito complex is still seen as a hunting focused economy with limited use of seed grinding technology. The economy is generally seen to focus on highly ranked resources such as large mammals and relatively high mobility which may be related to following large game (Gallegos 1992). Archaeological evidence associated with this period has been found around inland dry lakes, on old terrace deposits of the California desert, and also near the coast where it was first documented at the Harris Site.

Early Archaic Period

Native Americans during the Archaic period had a generalized economic focus on hunting and gathering. In many parts of North America, Native Americans chose to replace this economy with types based on horticulture and agriculture. Coastal southern California economies remained largely based on wild resource use until European contact (Willey & Phillips 1958). Changes in hunting technology and other important elements of material culture have created two distinct subdivisions within the Archaic period in southern California.

The Early Archaic period is differentiated from the earlier Paleoindian period by a shift to a more generalized economy and an increased focus on use of grinding and seed processing technology. At sites dated between approximately 8,000 and 1,500 years before present (B.P.), the increased use of groundstone artifacts and atlatl dart points, along with a mixed core-based tool assemblage, identify a range of adaptations to a more diversified set of plant and animal resources. Variations of the Pinto and Elko series projectile points, large bifaces, manos and portable metates, core tools, and heavy use of marine invertebrates in coastal areas are characteristic of this period, but many coastal sites show limited use of diagnostic atlatl points. Major changes in technology within this relatively long chronological unit appear limited. Several scientists have considered changes in projectile point styles and artifact frequencies within the Early Archaic period to be indicative of population movements or units of cultural change (Moratto 1984) but these units are poorly defined locally due to poor site preservation.

Late Archaic or Late Prehistoric Period

Around 2,000 B.P., Yuman-speaking people from the eastern Colorado River region began migrating into southern California, representing what is called the Late Prehistoric Period. The Late Prehistoric Period in San Diego County is recognized archaeologically by smaller projectile points, the replacement of flexed inhumations with cremation, the introduction of ceramics, and an emphasis on inland plant food collection and processing, especially acorns (True 1966). Inland semi-sedentary villages were established along major water courses, and montane areas were seasonally occupied to exploit acorns and piñon nuts, resulting in permanent milling features on bedrock outcrops. Mortar use for acorn processing increased in frequency relative to seed grinding basins. This period is known archaeologically in southern San Diego County as the Yuman (Rogers 1945) or the Cuyamaca Complex (True 1970).

The Kumeyaay (formerly referred to as Diegueño) who inhabited the southern region of San Diego County, western and central Imperial County, and northern Baja California (Almstedt 1982; Gifford 1931; Hedges 1975; Luomala 1978; Shipek 1982; Spier 1923) are the direct descendants of the early Yuman hunter-gatherers. Kumeyaay territory encompassed a large and diverse environment which included marine, foothill, mountain, and desert resource zones. Their language is a dialect of the Yuman language which is related to the large Hokan super family.

There seems to have been considerable variability in the level of social organization and settlement variability. The Kumeyaay were organized by patrilineal, patrilocal lineages that claimed prescribed territories, but did not own the resources except for some minor plants and eagle aeries (Luomala 1976; Spier 1923). Some lineages occupied procurement ranges that required considerable residential mobility, such as those in the deserts (Hicks 1963). In the mountains, some of the larger groups occupied a few large residential bases that would be occupied biannually, such as those occupied in Cuyamaca in the summer and fall, and in Guatay or Descanso during the rest of the year (Almstedt 1982; Rensch 1975). According to Spier (1923), many Eastern Kumeyaay spent the period of time from spring through autumn in larger residential bases in the upland procurement ranges, and wintered in mixed groups in residential bases along the eastern foothills on the edge of the desert (i.e., Jacumba and Mountain Springs). This variability in settlement mobility and organization reflects the great range of environments in the territory.

Acorns were the single most important food source used by the Kumeyaay. Their villages were usually located near water necessary for leaching acorn meal. Other storable resources such as mesquite or agave were equally valuable to groups inhabiting desert areas, at least during certain seasons (Hicks 1963; Shackley 1984). Seeds from grasses, manzanita, sage, sunflowers, lemonadeberry, chia and other plants were also used along with various wild greens and fruits. Deer, small game and birds were hunted and fish and marine foods were eaten. Houses were arranged in the village without apparent pattern. The houses in primary villages were conical structures covered with tule bundles, having excavated floors and central hearths. Houses constructed at the mountain camps generally lacked any excavation, probably due to the summer occupation. Other structures included sweathouses, ceremonial enclosures, ramadas and acorn granaries. The material culture included ceramic cooking and storage vessels, baskets, flaked lithic and ground stone tools, arrow shaft straighteners, and ornaments made of stone, bone or shell.

Hunting implements included the bow and arrow, curved throwing sticks, nets and snares. Shell and bone fishhooks as well as nets were used for fishing. Lithic materials including quartz and metavolcanics were commonly available throughout much of the Kumeyaay territory. Other lithic resources, such as obsidian, chert, chalcedony and steatite, occur in more localized areas and were acquired through direct procurement or exchange. Projectile points including the Cottonwood Series points and Desert Side-notched points were commonly produced.

Kumeyaay culture and society remained stable until the advent of missionization and displacement by Hispanic populations during the eighteenth century. The effects of missionization along with the introduction of European diseases, greatly reduced the native population of southern California. By the early 1820s California was under Mexico's rule. The establishment of ranchos under the Mexican land grant program further disrupted the way of life of the native inhabitants.

Ethnohistoric Period

The Ethnohistoric period refers to a brief period when Native American culture was initially being affected by Euroamerican culture and historical records on Native American activities were limited. When the Spanish colonists began to settle California, the project area was within the territory of a loosely integrated cultural group historically known as the Kumeyaay or Northern and Southern Diegueño because of their association with the San Diego Mission. The Kumeyaay as a whole speak a Yuman language which differentiates them from the Luiseño to the north who speak a Takic language (Kroeber 1925). Both these groups were hunter-gatherers with highly developed social systems. European contact introduced disease that dramatically reduced the Native American population and helped to break down cultural institutions. The transition to a largely Euroamerican lifestyle occurred relatively rapidly in the nineteenth century.

Historic Period

Cultural activities within San Diego County between the late 1700s and the present provide a record of Native American, Spanish, Mexican, and American control, occupation, and land use. An abbreviated history of San Diego County is presented here for the purpose of providing a background on the presence, chronological significance, and historical relationship of cultural resources within the county.

From the political perspective of western nations, Native American control of the southern California region ended with Spanish colonization of the area beginning in 1769. However, Native American control of the majority of the population of California did not end until several decades later. In southern California, Euroamerican control was only firmly established by the end of the Garra uprising in the early 1850s (Phillips 1975).

The Spanish Period (1769-1821) represents a period of Euroamerican exploration and settlement. Dual military and religious contingents established the San Diego Presidio and the San Diego and San Luis Rey Missions. The Mission system used Native Americans to build a footing for greater European settlement. The Mission system also introduced horses, cattle, other agricultural goods and implements; and provided construction methods and new architectural styles. The cultural and institutional systems established by the Spanish continued beyond the year 1821, when California came under Mexican rule.

The Mexican Period (1821-1848) includes the retention of many Spanish institutions and laws. The mission system was secularized in 1834 which dispossessed many Native Americans and increased Mexican settlement. After secularization, large tracts of land were granted to individuals and families and the rancho system was established. Cattle ranching dominated other agricultural activities and the development of the hide and tallow trade with the United States increased during the early part of this period. The Pueblo of San Diego was established during this period and Native American influence and control greatly declined. The Mexican Period ended when Mexico ceded California to the United States after the Mexican-American War of 1846-48.

Soon after American control was established (1848-present) gold was discovered in California. The tremendous influx of American and European migrants that resulted, quickly drowned out much of the Spanish and Mexican cultural influences and eliminated the last vestiges of de facto Native American control. Few Mexican ranchos remained intact because of land claim disputes and the homestead system increased American settlement beyond the coastal plain.

After the dissolution of the mission system and as late as 1920 Kumeyaay Indians continued to occupy the Tijuana River Valley until they were displaced by American and Mexican farmers. Many of these families eventually settled in Baja California. As a result, most of the ethnographic record concerns Eastern Kumeyaay who occupied the mountains and desert and who had little information to convey on coastal adaptations (Spier 1923; Gifford 1918, 1931; Kroeber 1925). This bias in the ethnographic record, plus early urbanization of the coastal areas before archaeological investigations could be undertaken, has resulted in an emphasis on inland terrestrial adaptive patterns as characterizing the Late Period occupation of San Diego County. A shift in this focus has occurred over the past decade with researchers examining more closely Late Period coastal adaptations (Gallegos 1992; Christenson 1992; Byrd 1998; Reddy 1992). An experimental agricultural colony was established just east of present day Border Field State Park in 1912. The colony was named San Ysidro and functioned for a short time until it was destroyed by the flood of 1916. During this flood, the Tijuana River rose rapidly above its banks and washed away houses on both sides of the border. This agricultural colony dissolved by 1918, largely due to the flood effects. With the beginning of World War II military activities, the U.S. Army established the Oneonta Gunnery School, which later became known as Ream Field. The Border Field area remained under military jurisdiction from 1941 to 1971.

The U.S. Navy used approximately 100 acres in the area for a 35 building facility known as Alf Landing Field, which was administered from Ream Field. Pilot gunnery training was provided by a steam-driven target that moved quickly among the dunes on a small-gauge railroad. These targets were nicknamed "rabbit tracks." Air-to-air gunnery practice was an important part of training in the area. Border Field was closed to the public from 1941 to 1951 due to war conditions.

9.3 Prior and Current Research

The most recent applicable cultural resources research in the project area was conducted by Tierra for the Model marsh project, a 20-acre wetland constructed as part of TETRP. The Model Marsh data recovery program included archival and other background studies in addition to Tierra's fieldwork. The archival research consisted of extensive literature and records searches at local archaeological repositories, in addition to an examination of historic maps, aerial photographs, and historic site inventories. This information was used to identify previously recorded resources and other evaluation projects that could be usefully compared to the Model Marsh project's results. The methods and results of the archival research are described below.

The records and literature search for the project was conducted at the South Coastal Information Center at San Diego State University and the San Diego Museum of Man. The records search included the entire Tijuana Estuary region north of the International Border. This area extends over five miles east of the project area to Otay Mesa, and about two and a half miles north of the

International Border to Imperial Beach. Historic maps provided by the South Coastal Information Center and the 1928 series of aerial photographs at the County of San Diego Cartographic Department were also examined.

The archaeology of the Tijuana Estuary region has been studied for over seventy years. Beginning with surveys in the 1920s by one of the pioneers in San Diego archaeology, Malcom Rogers, scientists have documented 61 prehistoric sites in the area, and 18 isolated prehistoric artifacts. The prehistoric cultural resources within the Tijuana Estuary region are summarized in Table 9-1. They suggest a variety of site types are present in the area ranging from shell scatters to habitation sites. The recurrent theme among the sites is shellfish and lithics, and most of the sites include one or both components. The sites are dominated by lithic scatters (n=36), and also include temporary camps (n=15), and quarries exploiting metavolcanic and volcanic stone (n=6). Shellfish forms a major part of many of these sites, and two sites are composed strictly of shell. Habitation sites are uncommon (n=2), but include the ethnographically documented Kumeyaay village of Millejo (CA-SDI-10669). Nearly all of the 18 isolates represent flaked lithic artifacts, dominated by flakes and cores, while the remaining two isolates are manos. Frequent flooding in the area has affected many of the resources. Five of the sites are buried, including the village of Millejo, and two sites represent redeposited materials in flood sediments. This indicates that the potential for buried sites in this region appears to be high. Most of the known range of human occupation of coastal California is represented in these sites, according to their recorders. At least ten of the sites were considered to date to the Paleoindian period or earlier. Seven sites were thought to have Early Archaic period components, and at least three were assigned to the Late Prehistoric period. The village of Millejo was thought to have been occupied from the Early Archaic period through at least 1850. This broad range of occupation indicates that the rich resources of the region have consistently attracted people over time.

While 49 archaeological investigations have taken place within the Tijuana Estuary region, the records search for the Model marsh project focused on comparable testing and evaluation projects in the region. Table 9-2 summarizes the 18 relevant archaeological evaluations within the Tijuana Estuary region.

9.4 Recent Model Marsh Investigations

In December 1999, an archaeological monitor with Tierra Environmental Services discovered a layer of artifacts and shell that had been washed into the marsh from a village further up the Tijuana River. Soon after, the lower sediments were pulled back to reveal a 1,700 year old picture of the lives of prehistoric inhabitants. This period is a poorly understood era of great change in the lives of the Kumeyaay. The bow and arrow replaced earlier weapons and the use of pottery and other ideas were imported from the east. It was also a time of great change in the marshes and estuaries of the San Diego coast. Many were silt filled and closed to the ocean, or nearly so, and some archaeologists believe the Kumeyaay migrated from these now less productive lagoons to San Diego Bay, which remained open. Other archaeologists believe the Kumeyaay adapted to these changes by intensifying their use of the land and acorn resources.

Table 9-1. Previously Recorded Prehistoric Resources in the Tijuana Estuary Region

State Trinomial	Museum of Man	Site Type	Period	Cultural Constituents	Recorder
CA-SDI-222	SDM-W-157	Habitation	San Dieguito/ La Jollan	Debitage, Shell, Hearths	Rogers
CA-SDI-2611	—	Lithic Scatter	pre-San Dieguito	Scrapers, Choppers, Cores	Moriarty and Carter
CA-SDI-3627	SDM-W-4589	Lithic Scatter, Historic Bunkers	San Dieguito	Flakes, WWII Bunkers	Moriarty
CA-SDI-4281	SDM-W-158	Temporary Camp/ Shell Midden	San Dieguito to Yuman III	1000s Debitage, Manos, Metates, Lithic Tools, Tizon Sherd, Worked Shell, Hearths, Shell, *Donax*, Animal Bone	Rogers
CA-SDI-4571	—	Quarry	Unknown	Hammerstone, Core, Flakes, Scraper, FAR, Retouched Tools	Cook
CA-SDI-4641	—	Temporary Camp	Unknown	Chopper, 100s of Manos, 20 Flakes, Animal Bone	Wallace
CA-SDI-4933	SDM-W-1243	Temporary Camp	Unknown	Cores, Flakes, Core/Flake Tool, *Chione, Pecten, Ostrea, Mytilus*	Collett
CA-SDI-4934	SDM-W-1244	Lithic Scatter	Unknown	3 Retouched Tools, 50 Flakes	Collett and Wade
CA-SDI-4934C	—	Lithic Scatter	Unknown	10+ Flakes	Hannah
CA-SDI-7456	SDM-W-2418	Lithic Scatter	San Dieguito	Flakes	Polan
CA-SDI-8595	SDM-W-2899	Temporary Camp/ Historic Trash	Unknown	Flake, Mano, Chopper, Worked *Tivella*, Shell, Historic Trash	Polan
CA-SDI-8596	SDM-W-2900	Lithic and Shell Scatter	Unknown	12 Flakes, Shell	Polan
CA-SDI-8597	SDM-W-2901	Lithic Scatter	Unknown	Cores, Scrapers, Flakes	Polan
CA-SDI-8598	SDM-W-2902	Lithic and Shell Scatter	Unknown	2 Cores, Hammerstone, Shells	Polan
CA-SDI-8599	SDM-W-2903	Lithic Scatter	Unknown	Cores, Flakes, Core-Chopper, Hammerstone, Shell	Polan
CA-SDI-8600	SDM-W-2904	Lithic Scatter	Unknown	2 Hammerstones, 1 Scraper	unknown
CA-SDI-8602	SDM-W-2906A	Lithic Scatter	Unknown	Flakes, Cores, Scrapers, Hammerstones, Utilized Flakes, Anvil	Polan
CA-SDI-8603	SDM-W-2907	Lithic Scatter	Unknown	Flakes, Cores, Scrapers, Hammerstones	Polan
CA-SDI-8604	SDM-W-2908	Quarry, Temporary Camp	San Dieguito III	Flakes, Cores, Tools, Hammerstones, *Argopecten*	Polan
CA-SDI-8605A	SDM-W-388	Quarry	San Dieguito III to Yuman III	Scrapers, Cores, 100+ Flakes	Poe
CA-SDI-8605B	SDM-W-388-B	Redeposited Lithics and Shell	Unknown	Hammerstones, Cores, Shell	Polan
CA-SDI-8750	SDM-W-2963	Lithic Scatter	Unknown	Cores, Scrapers, Flakes	Apple
CA-SDI-8751	SDM-W-2964	Lithic Scatter	Unknown	2 Cores, 1 Scraper, Flakes	Apple
CA-SDI-8752	SDM-W-2965	Lithic Scatter	Unknown	Flakes	Apple
CA-SDI-8753	SDM-W-2966	Lithic Scatter	Unknown	2 Cores, 1 Scraper, 2 Flakes	Apple
CA-SDI-8773	—	Prehistoric Scatter/ Historic Adobe	Paleo-Indian	Not Described	Campbell
CA-SDI-9181	SDM-W-3645	Temporary Camp		Flakes, Cores, *Pecten, Chione*	Henry, Berryman, Heuett

Table 9-1. Continued

State Trinomial	Museum of Man	Site Type	Period	Cultural Constituents	Recorder
CA-SDI-9182	SDM-W-3646	Lithic and Shell Scatter	Unknown	Flakes, Core, *Pecten, Chione*	Henry, Heuett, Berryman
CA-SDI-9183	SDM-W-3647	Temporary Camp	Unknown	Mano, Flakes, *Pecten, Chione*	Henry and Brown
CA-SDI-10209	SDM-W-3602	Lithic Scatter	Unknown	Debitage	Robbins-Wade
CA-SDI-10210	—	Quarry	Unknown	Flakes, Cores, Utilized Flakes, 1 Mano	Hannah
CA-SDI-10486	—	Lithic and Shell Scatter	Unknown	3 Flakes, 1 Angular Waste, *Mytilus, Pecten, Ostrea, Chione*	Pigniolo and Christenson
CA-SDI-10487	—	Shell Scatter and Flake	Unknown	1 Flake, *Chione*	Collett and Wade
CA-SDI-10511	—	Temporary Camp	San Dieguito/ La Jollan	Scrapers, Cores, Flakes	Pigniolo
CA-SDI-10613	—	Lithic Scatter	Unknown	3 Flakes, 1 Tool	Hector
CA-SDI-10614	—	Quarry	Unknown	Cores, Flakes	
CA-SDI-10639	—	Shell Scatter	Unknown	*Donax*	
CA-SDI-10669	SDM-W-1140	Ethnographic Village of Millejo	La Jollan through 1850	Buried Site: *Chione, Mytilus*, Flakes, Cores, Scraper, Tools, Possible Hearths	Shipek
CA-SDI-10966	—	Quarry?	Upper Pleistocene	Large Boulder Core	Carter
CA-SDI-10967	SDM-W-2460	Lithic Scatter/ Shell Midden	La Jollan?	Shells, 3 Flakes	Roeder
CA-SDI-11079	—	Temporary Camp	San Dieguito/ La Jollan	Scrapers, Cores, Flake Tools, Hammerstones, Mano, 200+ Flakes, *Chione, Mytilus*, Hearth	Pigniolo
CA-SDI-11097	—	Lithic Scatter	Unknown	Flakes, Core	Cook and Serr
CA-SDI-11098	—	Lithic Scatter	Unknown	4 Flakes, Core	Cook and Serr
CA-SDI-11099	—	Temporary Camp	Late Prehistoric	Hammerstones, Cores, Flakes, Scrapers, Choppers, Mano, Tizon Sherds, *Chione, Mytilus, Argopectin*	Cook and Serr
CA-SDI-11100	—	Lithic Scatter	Unknown	2 Cores, 126 Flakes, 1 Uniface	Cook and Serr
CA-SDI-11101	—	Lithic Scatter	Unknown	1 Core, 5 Flakes, 1 Angular Waste	Cook and Serr
CA-SDI-11544	SDM-W-4843	Lithic Scatter	Unknown	100-130 Flakes	Collett and Harden
CA-SDI-11545	SDM-W-4354	Redeposited Temporary Camp	Unknown	Flakes, Core, Manos, *Chione*	Collett and Harden
CA-SDI-11945	—	Lithic Scatter	Unknown	25+ Flakes, Core, Tools	Ritz and Dans
CA-SDI-11946	—	Lithic Scatter	Unknown	40 Flakes and Angular Waste	Ritz and Dans
CA-SDI-12455	SDM-W-4353	Lithic and Shell Scatter	Unknown	Debitage, FAR, Shell	Alter and Gross
CA-SDI-12456	SDM-W-4844	Lithic and Shell Scatter	Unknown	Core, 3 Flakes, Shell (mostly *Chione*)	Coleman and Goldborer
CA-SDI-12962H	—	Historic and Prehistoric Artifacts	Historic/ Unknown	Prehistoric Component is CA-SDI-4934	Pierson and Smith
CA-SDI-13485	SDM-W-6303	Temporary Camp	Unknown	Buried Site: 7 Flakes, 2 Hearths, 1 *Chione*	Coleman and Goldborer
CA-SDI-13486	—	Lithic Scatter	Unknown	Buried Site: 1 Core, 4 Flakes, FAR	Pigniolo

Table 9-1. Continued

State Trinomial	Museum of Man	Site Type	Period	Cultural Constituents	Recorder
CA-SDI-13487	SDM-W-6532	Temporary Camp	Unknown	Buried Site: Chopper, Pecking Stone, Mano, FAR, Shell	Pigniolo
CA-SDI-13488	—	Temporary Camp	Unknown	Buried Site: 3 Utilized Flakes, Scraper, Metate, 2 Hearths, Shell	Perry
CA-SDI-13527	SDM-W-1375	Temporary Camp	San Dieguito	20+ Artifacts: Flakes, Cores, FAR, Shell	Carrico
CA-SDI-13718/H	SDM-W-6427	Lithic Scatter/ Historic Trash	Unknown	1Retouched Flake, Shell, Historic Trash	Adams
CA-SDI-15038	—	Lithic Scatter	Unknown	400-800 Flakes, 1 Shell	Buysse et al.
CA-SDI-15099	SDM-W-1376	Lithic Scatter	Unknown	4 Flakes, 1 Scraper	Carrico
I-289	SDM-W-4529-A	Isolate	Unknown	Unifacial Metavolcanic Scraper	Robbins-Wade
I-290	SDM-W-4529-B	Isolate	Unknown	Metavolcanic Flake	Robbins-Wade
I-291	SDM-W-4530-A	Isolate	Unknown	Metavolcanic Core	Robbins-Wade
I-292	SDM-W-4530-B	Isolate	Unknown	Metavolcanic Core	Robbins-Wade
I-294	SDM-W-4530-D	Isolate	Unknown	Metavolcanic Uniface	Robbins-Wade
I-456	—	Isolate	Unknown	Core	Robbins-Wade
I-11545-2	—	Isolate	Unknown	Metavolcanic Core (part of CA-SDI-13527?)	
I-11545-3	—	Isolate	Unknown	Metavolcanic Flake	
I-11545-4	—	Isolate	Unknown	Metavolcanic Flake	
I-11545-5	—	Isolate	Unknown	Metavolcanic Core	
I-11545-6	—	Isolate	Unknown	Metavolcanic Core	
I-11545-7	—	Isolate	Unknown	Metavolcanic Flake (part of CA-SDI-13527?)	
I-11545-8	—	Isolate	Unknown	Metavolcanic Retouched Flake (part of CA-SDI-13527?)	
I-11545-9	—	Isolate	Unknown	Sandstone Mano (part of CA-SDI-4933?)	
I-11545-10	—	Isolate	Unknown	2 Metavolcanic Flakes (part of CA-SDI-13527?)	
I-11545-11	—	Isolate	Unknown	Metavolcanic Flake (part of CA-SDI-13527?)	
I-11545-12	—	Isolate	Unknown	Quartzite Mano Fragment	
I-11545-13	—	Isolate	Unknown	2 Metavolcanic Flakes (part of CA-SDI-13527?)	

Table 9-2. Relevant Archaeological Investigations Within the Tijuana Estuary Region

Author	Date	Project
Adams & Turnbow	1994	Supplemental Report: Archaeological Survey and Geotechnical Test Monitoring of the International Wastewater Treatment Plant Ocean Outfall Tunnel.
Baksh	1996	Negative Archaeological Survey Report: The Hollister Street Project.
Bingham	1978	Archaeological Test Excavations Within Border Field State Park, San Diego County
Carrico & Dietler	1998	Cultural Resources Evaluation for the South Bay Reclamation Sewer and Pump Station Project San Diego County.
Cheever & Gallegos	1987	Cultural Resource Survey for the Smuggler Gulch Surface Flow Collection Facility, San Diego, California.
City of San Diego	1994	**Report is lost but boundary remains on maps at SCIC**
Collins	2000	Monitoring and Discovery Plan for Tijuana Slough National Wildlife Refuge Drum Removal.
Douglas & Stickel	1980	An Underwater Cultural Resource Records Check and Literature Search, South Bay Ocean Outfall Project, Imperial Beach, San Diego County, California.
Gallegos	1986	Cultural Resource Survey and Significance Testing for the International Wastewater Project
Gallegos & Kyle	1997	Cultural Resource Survey for the Imperial Beach Border Patrol Station Expansion San Diego, California.
Higgins	1994	Archaeological Monitoring of the International Wastewater Treatment Plant Land Outfall Trench.
Higgins	1994	Archaeological Investigations at the Proposed International Wastewater Treatment Plant Site: Cultural Resource Identification and Geotechnical Test Monitoring.
International Boundary and Water Commission	1987	Draft Environmental Assessment International Surface Flow Collection Facility at Smuggler Gulch Baja California, Mexico and San Diego County, California.
Manley	1993	Historic Assessment of 3 parcels on Monument Road, San Diego, California
Pettus	1994	Draft Remote Sensing Marine Cultural Resource Survey of Proposed South Bay Ocean Outfall Diffuser Locations and Anchorage Areas U.S./Mexican Border.
Pigniolo et. al.	1986	Cultural Resource Survey and Test for Significance of Archaeological Site CA-SDI-9183 at a Proposed Border Patrol Station, Southeast Imperial Beach, California.
Pigniolo & Baksh	1998	Cultural Resource Inventory for the Tijuana Estuary Restoration Project/Model Marsh Border Field State Park, California.
Pigniolo & Baksh	1999	Archaeological Survey Report for the Model Marsh Soil Stockpile and Quarry Restoration Project, City of San Diego, California.
Pigniolo	2001	Cultural Resource Monitoring Report for the Hollister Street Bailey Bridge Replacement Project, San Diego County, CA.
Polan	1981	An Archaeological Reconnaissance of Border Highlands, San Diego, California
Sampson	1986	An Archaeological Survey of the Proposed Visitor Center Border Field State Park Southwestern San Diego County.
Schwaderer	1986	Archaeological Test Excavations at CA-SDI-4281, Border Field State Park, San Diego County
Turnbow et. al.	1995	Archaeological Testing of Three Sites for the International Wastewater Treatment Plant Project San Diego County, California.
Van Wormer	1999	Cultural Resource Evaluation of Site CA-SDI-14831 for the Tijuana Estuary Restoration Project/Model Marsh Border Field State Park, California.
Woodward	1985	Restoration of Tidal Flow and Rebuilding of Dunes, Border Field State Park

The Kumeyaay, who gathered food from Tijuana Estuary, moved with seasonal resources along the river valley. They came to the marsh primarily to gather and prepare shellfish. The stratigraphic picture at the Model Marsh reveals how small groups of Kumeyaay used a spit of sand that protruded into the marsh as a base for their shellfish processing operation. They camped on the sand and collected their tidal harvest for steaming or baking.

Mounds of partially burned shell and bone attest to the meals cooked here at the edge of the tides. The site includes thousands of oysters, scallops, and clams in addition to numerous other shellfish species. It is interesting to note that after shellfish, the animal remains found at the Model Marsh were dominated by small land animals, including rabbits and gophers. Other foods included larger mammals, sharks or rays, smaller fish such as sardine, croaker, corvina, surfperch, and sheephead, duck and plover, crab, snake, lizard, and pond turtle. In addition to enjoying the fare of the estuary, the Kumeyaay made limited tools at their campsite from local cobbles.

The layered structure of a fish earbone can identify what season it was caught and what time of year the site was occupied. The earbones found at the Model Marsh demonstrate that the area was visited during the winter and spring.

Radiocarbon dates of the shellfish reveal a long history of repeated visits to the marsh to harvest its resources. These dates range from 1,705 to 835 years before present, or AD 245 to AD 1115. Changes in the types of shell they gathered over this 875 year long period reflect differences in the environment. The earliest heaps of shell are large and diverse, containing many species of shellfish and other animals, but are dominated by clams. These great piles reflect a healthy estuary or lagoon environment containing an abundance of food that was exploited. But later deposits show a changing focus and a diminished scope in the Kumeyaay gathering activities. These smaller piles are dominated by only one type of shell, usually oysters, and may indicate that the estuary was becoming closed to tidal flushing. Less hardy species could no longer thrive in the marsh, limiting the Kumeyaay to the few species remaining. Some of the latest deposits contain only very small piles of jackknife clams, which one could assume outlasted even the oysters in the increasingly inhospitable marsh. Sometime after AD 1115, no shellfish remained for the Kumeyaay to gather, or the sand spit could no longer be used as a campsite.

Trenching Study to Assess Potential Project Impacts

A synthesis of existing cultural resource studies for the project area was prepared by Tierra and incorporated in this feasibility and design study. One of the results of that synthesis was the acknowledgement that subsurface testing was required in order to assess the potential impacts of the project on buried cultural resources. Accordingly, a sampling plan was developed and implemented that included a number of trenches excavated by backhoe to assess these resources. The results of that sampling plan are presented below.

The trenching study involved excavating 49 backhoe trenches within the project area to identify the number and amounts of buried cultural resources that might be impacted by the proposed restoration of the marsh. Prior to commencing excavation of the trenches, Tierra conducted a review of several cultural resources studies and an archaeological survey for a project area of approximately 560 acres within and adjacent to the Tijuana Estuary in Borderfield State Park. The goal of the literature review was to identify locations within and immediately adjacent to the project area where prehistoric and historic cultural resources are both known to exist. The remaining areas, including both surface and subsurface areas, represent data gaps. Based on the results of the literature review, a survey was undertaken in portions of the 560-acre study area that had previously not been surveyed and where biological sensitivity was not an issue. This survey resulted in the identification of seven cultural resources including both prehistoric and historic forms. The information obtained was used to guide the planning process and develop the current testing program to determine locations where backhoe trenching was applicable for the identification of subsurface cultural resources. Before entering the field, a 100-meter grid was laid over a geo-referenced aerial photo of the project area. Trenches were selected by using grid intersections for locations. Areas of biological sensitivity were removed from consideration for trenching, leaving a total of 49 trenches that were excavated (Figure 9-1). The trenches were dug in order to determine the presence or absence of cultural remains within a given trench and to gain insight into the number and types of cultural resources that might be encountered if the when the project commences. Once in the field, the trench locations occasionally varied from the 100-meter grid when necessary to avoid damaging native vegetation. Trenches were excavated, until collapsing walls precluded digging deeper or until groundwater seepage made going deeper infeasible. The trenches were dug to a width of approximately 24 inches and a length of 15 feet.

The trenching program resulted in the identification of two cultural resources, one prehistoric shell midden and a World War II era collection of metal hardware found in a matrix of oil drenched soil. Thus, it is not anticipated that buried cultural resources will pose a significant constraint to construction of any of the alternatives developed for the Tijuana Estuary – Friendship Marsh Restoration.

Figure 9-1. Project Area Showing Individual Trench Locations

10.0 RECREATION AND PUBLIC ACCESS

The beauty of the tidal marshes and wildlife of Tijuana Estuary have long attracted passive recreational users, such as birders and nature enthusiasts. The Tijuana Estuary Visitor Center, constructed in 1991, provides educational programs and displays that explain the ecology of the estuary. Numerous trails have been constructed around the visitor center and in other areas in the north arm of the estuary. These trails allow visitors to view selected portions of the estuary while restricting access to sensitive habitats and species.

California State Parks (CSP) and the U.S. Fish and Wildlife Service (USFWS), co-managers of the Tijuana River National Estuarine Research Reserve, developed a number of Reserve-wide policies regarding public access and public use. One such policy is to encourage wildlife-oriented recreation, including wildlife observation, photography, interpretation and education. Other forms of recreation, such as hiking, horseback riding and beach use are also encouraged wherever they are compatible.

10.1 Public Access

The Comprehensive Management Plan for the Tijuana River National Estuarine Research reserve and Tijuana Slough National Wildlife Refuge (Management Plan; CONCUR July 2000) identified the following perceived needs for public access:

- Improve Monument Road access through expanded entrance hours, enhanced roadway conditions, and additional roadside facilities.
- Improve signage on Monument Road to better direct visitors to Border Field State Park.
- Improve signage on Route 75 and Interstate 5 to better direct the public to the visitor center.
- Provide interpretive signs, trail signs and directions to parking.
- Increase the visibility of operating agencies in the southern end of the Reserve.
- Better explain Reserve management to the public.
- Develop a large-scale effort to plan and improve accessibility to the southern end of the Reserve.

The Goat Canyon Enhancement Plan, completed in 2005, included improvements to Monument Road to provide better access to the Border Field State Park and the southern end of the estuary. Portions of the road were elevated, a multi-use trail was constructed along a portion of the road, and new entrance kiosk was constructed. However, a section of the road that was not elevated washed out during the heavy rainfall of 2005. This wash-out coupled with increased water flow and sediment deposition from Yogurt Canyon near Monument Mesa has continued to restrict entrance and use of Border Field State Park. The park is currently closed to the public.

10.2 Public Use

The majority of the public use at the estuary takes place on refuge lands in the northern end of the system and the beaches of Border Field State Park in the south. The Management Plan estimated approximately 85,000 visitors to the Reserve in 1997, dominated by hikers (21,000), equestrians (13,000) and beach users (30,000).

The following perceived needs in public use were identified in the Management Plan:

<u>Foot Trail Use Needs.</u>

- An improved, accessible trail is needed along the eastern boundary of the Reserve. Interpretive signs need to be developed and installed.
- Improved access is needed to Border Field State Park, as well as well-marked trailheads, parking areas and improved signage.

<u>Equestrian Trail Use Needs</u>.

- The operating agencies, landowning agencies, the Tijuana Equestrian Association and the Mounted Assistance Unit need to develop and implement a memorandum of understanding (MOU) relating to trail routing, maintenance and use.
- An improved trail linkage from the area of the Border Patrol headquarters to the west end of Sunset Avenue is needed and should be designated, with consideration for endangered species.
- New river crossings are needed to provide safe access to the south side of the Reserve.
- Equestrian use and safety must be addressed in plans to rehabilitate and/or relocate Monument Road.
- Wetland restoration projects in the southern end of the Reserve should integrate trail access needs and trails should be included in the engineering plans for marsh restoration projects.
- Corral and latrine facilities at Border Field State Park need to be upgraded and kept open during park hours.
- Any new trails should be designed to serve multiple needs to reduce the area disturbed by trail construction.
- Proposals for any new recreation uses of the Reserve (e.g., mountain biking) must be carefully analyzed to ensure that they are compatible not only with resource protection, but also with existing authorized uses such as horseback riding.
- Additional education and enforcement efforts are needed to ensure equestrian compliance with leash laws and area closures for endangered species.

- The operating agencies and County Parks need to negotiate a Special Use Permit system for all commercial operators to ensure that businesses profiting from public lands are held accountable for the actions of their customers.

- The operating agencies should organize a training program for business owners and their guides to orient them to the purpose, rules, and regulations of the Reserve.

- Consistent signage needs to be established to improve public awareness of the Reserve's identity and its boundaries.

- Signage and public awareness about the importance of keeping dogs leashed needs to be improved.

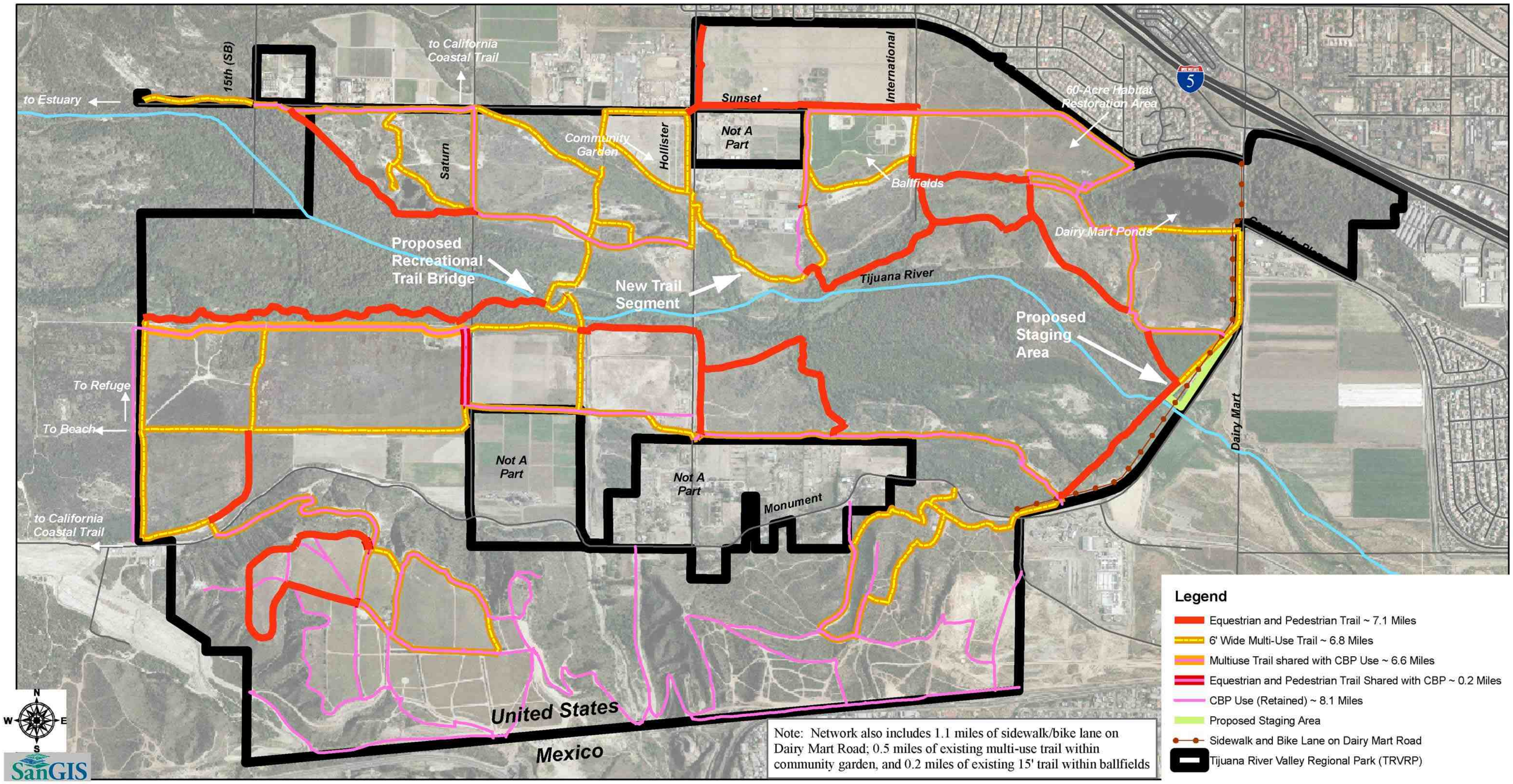
Some of these perceived needs regarding public access and use have been addressed since the last revision of the Management Plan. For example, an MOU was developed between operating agencies and equestrians, and education efforts have been expanded. However, as demonstrated above, many of the perceived public use needs were associated with equestrian use of trails and the beach.

Historically, equestrians have accessed the beach from a number of trails that converge into one east-west trail that extends from Monument Road before it turns south towards Monument Mesa. This trail provides a straight route to the beach that is rarely used by vehicles.

In order to improve access to the public and preserve the sensitive resources of the estuary, the County of San Diego recently conducted a study of trail use in the southern Tijuana River Valley in the County's 1,800-acre Tijuana River Valley Regional Park (TRVRP). The study and subsequent Environmental Impact Report (EIR) developed a Preferred Alternative with a formal recreational trail network consisting of 22.5 miles of multi-use trails and a staging area within the park (Figure 10-1). In addition to the designation of 22.5 miles of official trails, the study identified approximately 41 miles of unofficial trails that would be closed and revegetated. The western terminus of the trail system is near the Goat Canyon Sedimentation Basins and the proposed Tijuana Estuary – Friendship Marsh Restoration Feasibility and Design Study project area.

According to the study, visitors to the TRVRP will use the formal trails system for hiking, biking, riding horses and other passive recreation, such as bird watching. The trails would also be used for Border Patrol access. The proposed project would create, enhance, and restore natural habitats within the TRVRP while optimizing the recreational use of the site and accommodating ongoing border protection activities. The primary competing interests for the trails project are related to equestrian use and habitat protection.

The equestrian community has a long history in the project area. Until recently, commercial stables provided rental horses to customers seeking the unique experience of horseback riding on the beach. Border Field State Park is one of the few places in California where this is allowed on the beach, although this practice is not always embraced by the environmental community. The majority of rental stables are no longer in business; however, the beach remains open for the local equestrian community. Equestrians would prefer the designation of more formal,



K:\095432014\GIS Exhibits\x-formal trail network.mxd

Sources

Figure 10-1
Formal Trail Network

equestrian-only trails as they are concerned about safety conflicts between horses and other trail users. The equestrian community asserts that horses provide benefits to the local community, and to public health and safety, and that horses do not negatively affect sensitive habitats and species.

In contrast, environmental agencies, organizations, and individuals support closure of much of the informal trail system for habitat protection and restoration. The concerns of this group include the protection of sensitive species from impacts related to human recreation, trail maintenance and invasive species.

10.3 Trails

The site of the proposed Tijuana Estuary - Friendship Marsh restoration is part of Borderfield State Park and an important site for recreation. When access is available, the project area is used by hikers, birders, horseback riders and beachgoers. The vast majority of these activities will continue or be enhanced after the restoration is complete. However, the trail that currently provides equestrians with a straight route to the beach would be eliminated by the project.

In order to accommodate equestrians and other trail users while complying with the identified need for integration of trail access needs in marsh restoration projects, alternate beach access routes have been devised. These are presented below.

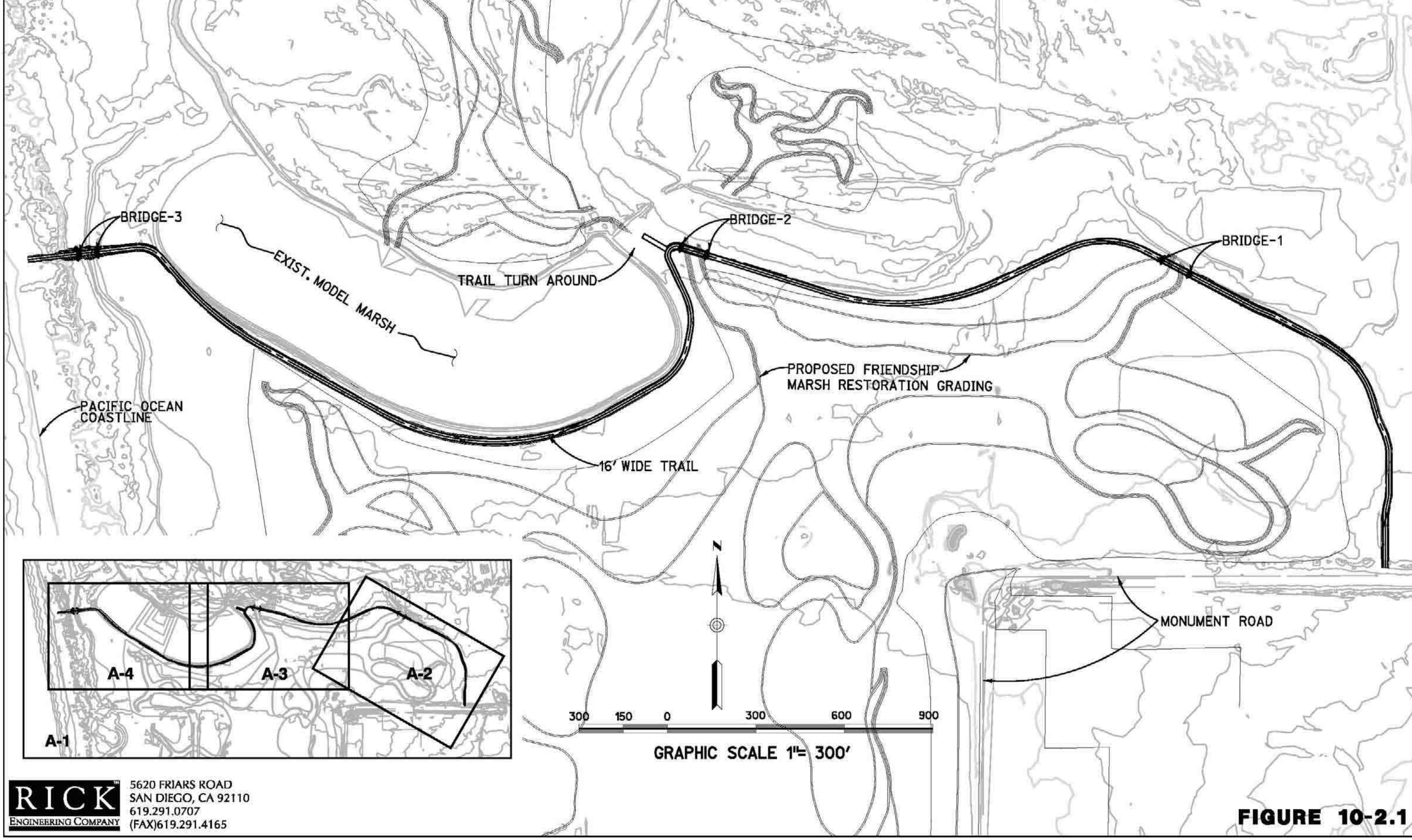
10.4 Trail Alternatives

10.4.1 Bridged Alternative

The most complex alternative would include an improved multi-use trail that would follow existing trails and the berm that currently protects the Model Marsh (Figure 10-2). This trail would be approximately 1.2 miles long and would feature a decomposed granite surface and include three prefabricated bridges. The trail would be 16 feet wide to accommodate multiple users, e.g., hikers and equestrians. This width would narrow to 12 feet at each bridge. The trail would elevated to prevent damage from extreme tides expected once the tidal flushing in the southern arm is improved by the restoration plan. It is anticipated that the trail would be used by equestrians, hikers and bicyclists. Hikers and cyclists would be informed by signage to wait for any horses to cross the bridges should they arrive simultaneously.

The cost of the improved trail is illustrated in Table 10-1. Assuming that each prefabricated bridge will cost approximately $125,000, it is estimated that the 1.2-mile trail can be constructed for approximately $1,225,600. A complete preliminary design analysis for the multi-use trail is provided in Appendix H.

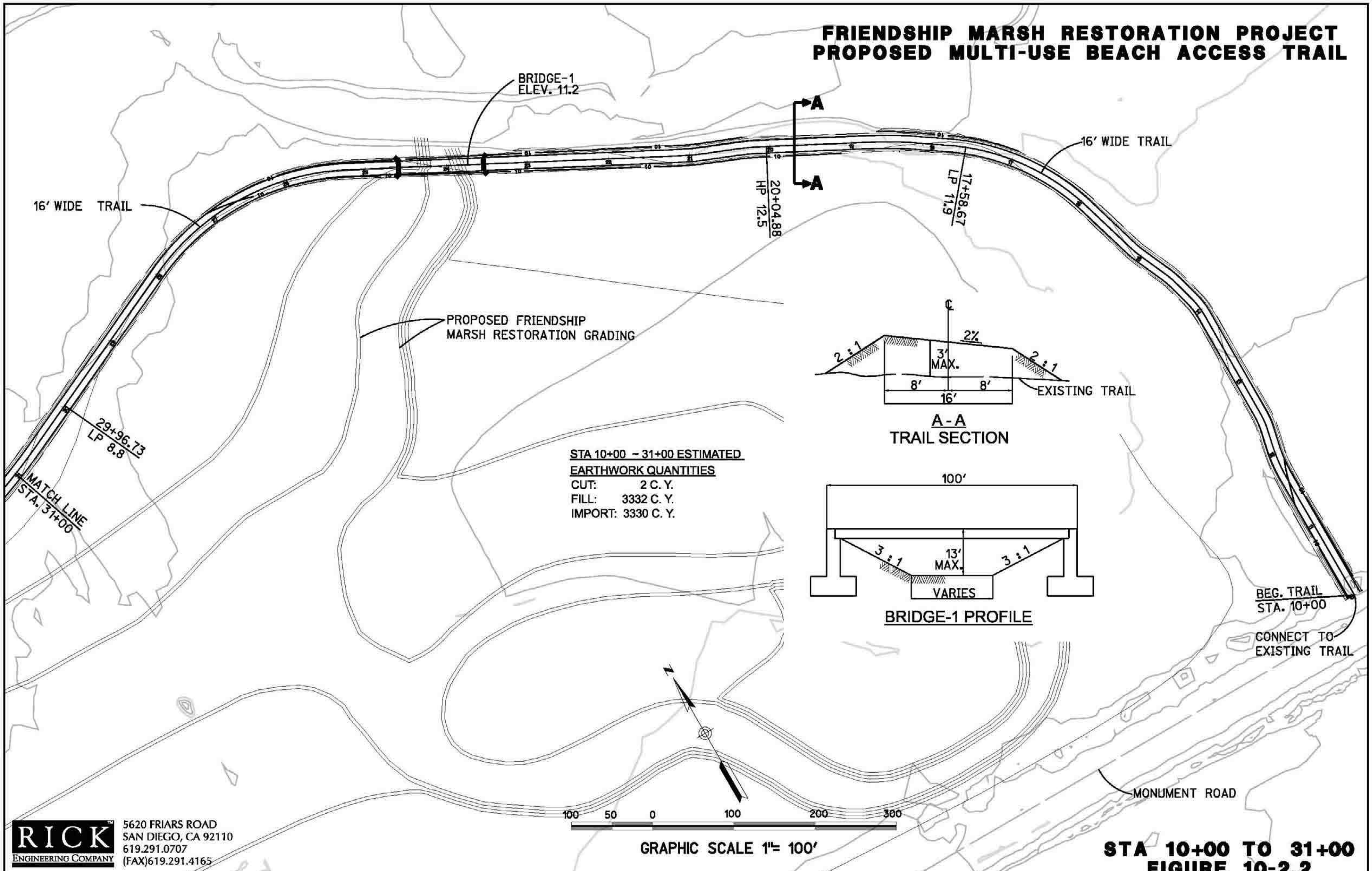
FRIENDSHIP MARSH RESTORATION PROJECT
PROPOSED MULTI-USE BEACH ACCESS TRAIL



RICK ENGINEERING COMPANY
5620 FRIARS ROAD
SAN DIEGO, CA 92110
619.291.0707
(FAX)619.291.4165

FIGURE 10-2.1

FRIENDSHIP MARSH RESTORATION PROJECT
PROPOSED MULTI-USE BEACH ACCESS TRAIL



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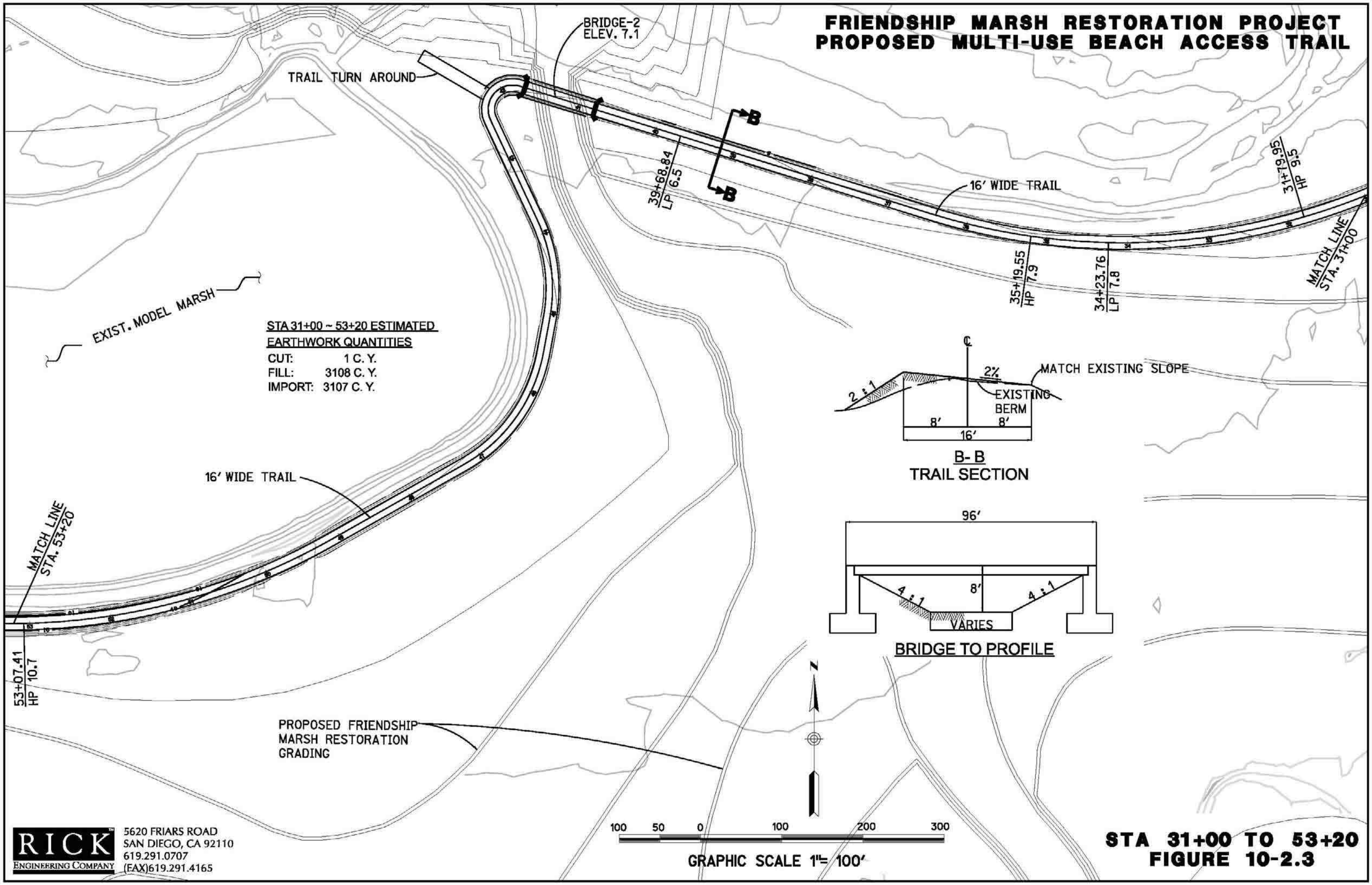
(FAX)619.291.4165

STA 10+00 TO 31+00
FIGURE 10-2.2

FRIENDSHIP MARSH RESTORATION PROJECT
PROPOSED MULTI-USE BEACH ACCESS TRAIL



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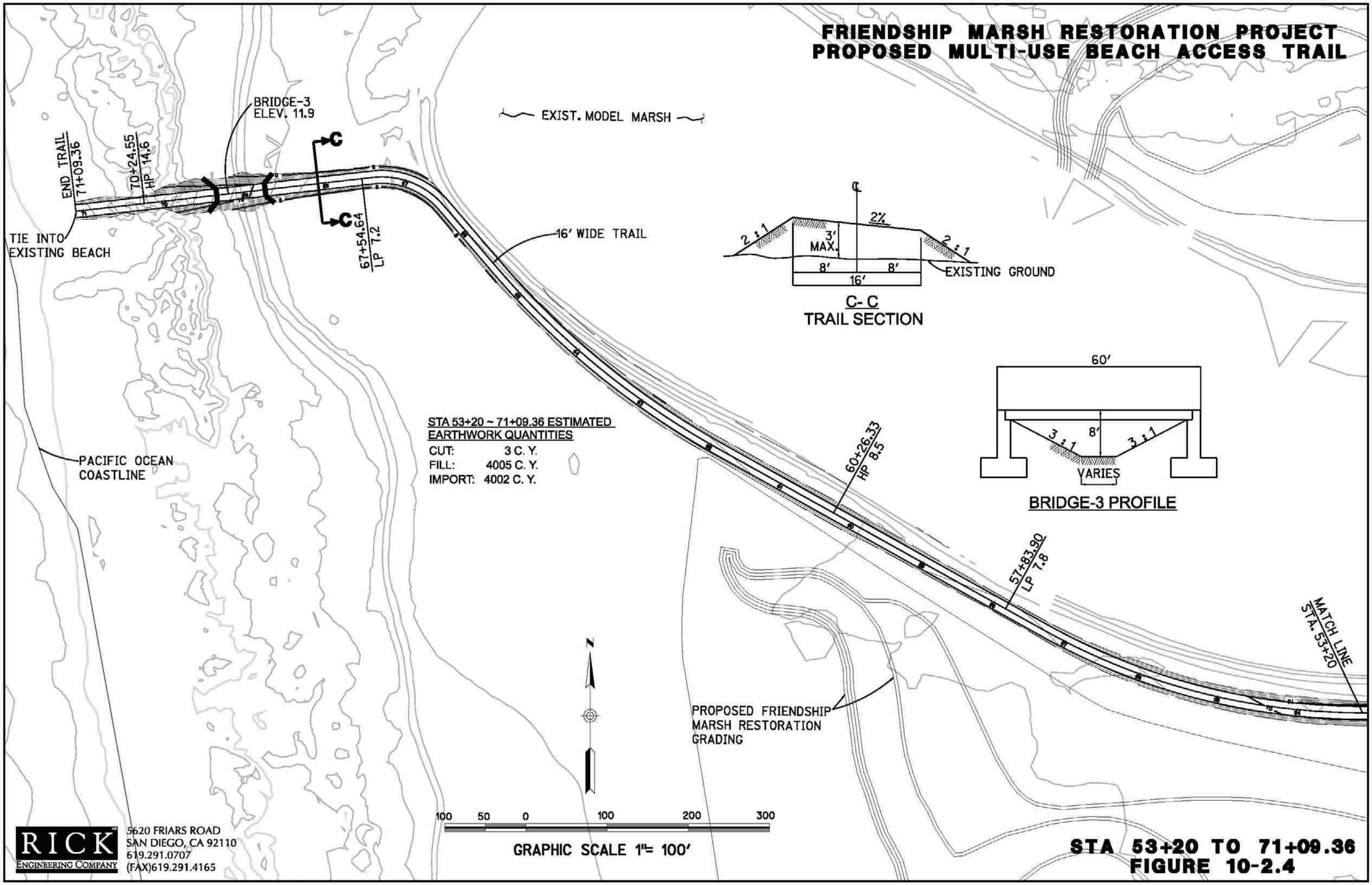
(FAX)619.291.4165

STA 31+00 TO 53+20
FIGURE 10-2.3

FRIENDSHIP MARSH RESTORATION PROJECT
PROPOSED MULTI-USE BEACH ACCESS TRAIL



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STA 53+20 TO 71+09.36
FIGURE 10-2.4

Table 10-1. Equestrian Trail - Estimate of Probable Construction Cost

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$10,000.00	$10,000.00
Clearing & Grubbing	1	LS	$10,000.00	$10,000.00
Grading/ Earthwork	10450	CY	$10.00	$104,500.00
Trail Surface	6110	LF	$20.00	$122,200.00
12' Wide Bridge (100' Span)	3	EA	$125,000.00	$375,000.00
Bridge Abutments (Pair) - Pilings	3	EA Pair	$80,000.00	$240,000.00
Slope Protection/ Landscape	5950	SY	$2.00	$11,900.00
			Subtotal:	**$873,600.00**
			5% Contingency:	$43,700.00
			25% Final Engineering/ landscape/ survey	$218,400.00
			10% (Bridge Cost) Structural Engineering	$37,500.00
			6% Soils Engineering	$52,400.00
			Environmental Services	*undetermined*
			Total:	***$1,225,600.00***

Construction of this trail would result in impacts to existing habitats as well as a loss of a small area planned as mid-high marsh (Table 10-2; Figure 10-3). Some of the impacts would be considered permanent, i.e., the existing habitats would be converted to trail. Temporary impacts associated with a 5-foot-wide construction buffer would be replanted with native species as mitigation. Permanent impacts total 3.46 acres and temporary impacts include 1.40 acres (Table 10-2).

The construction of the proposed multi-use trail would result in a permanent reduction of approximately 2.76 acres of the proposed wetland habitat restoration associated with the Friendship Marsh Restoration Project Preferred Alternative (Table 10-3). The trail would also result in a temporary reduction of approximately 1.07 acres of the proposed wetland habitat restoration due to the construction footprint.

Other less costly alternatives were developed to accommodate trail users. These include the Spooner's Mesa alternative and the Monument Road alternative, as described below.

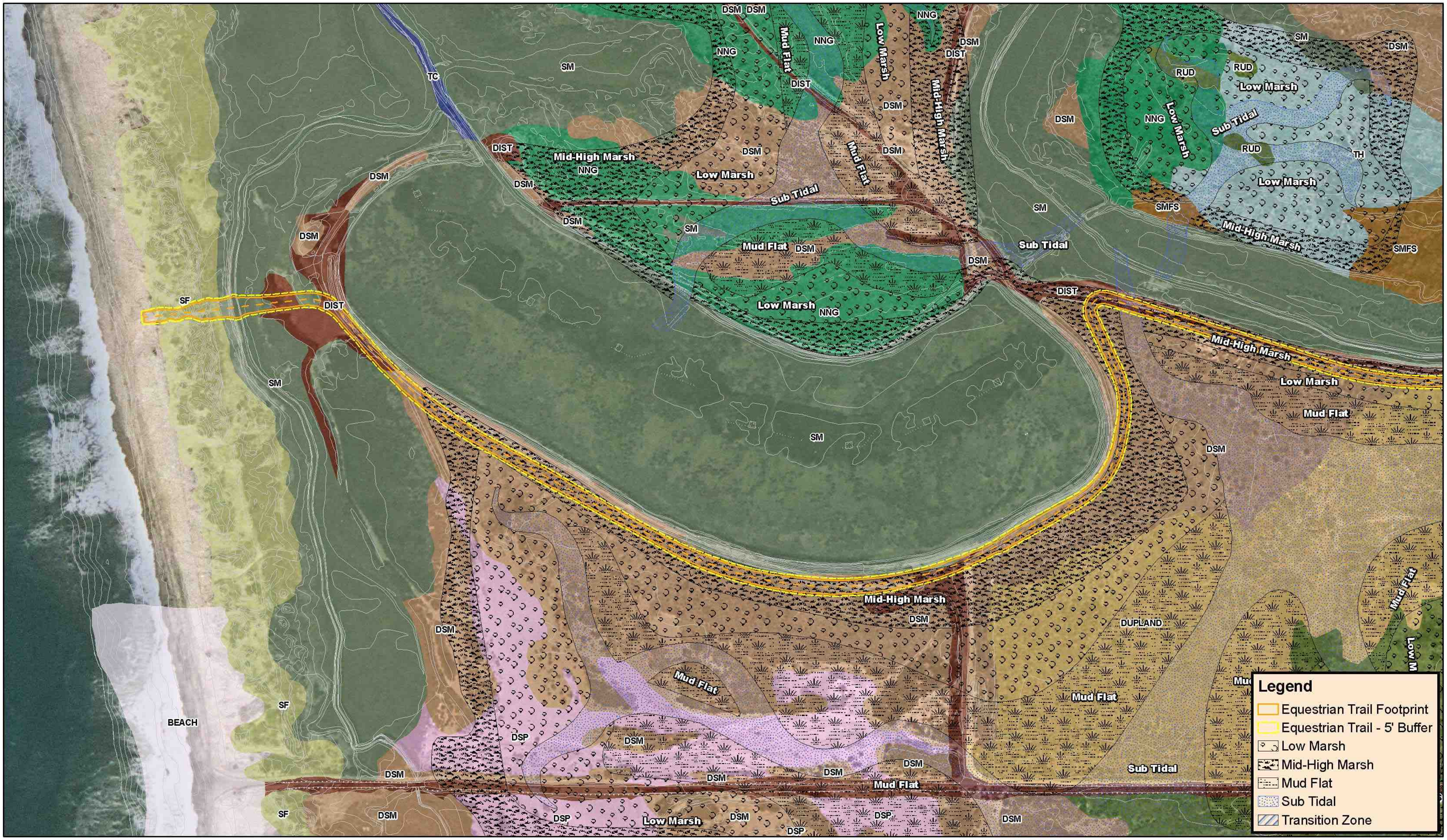

FIGURE 10-3.1

HABITAT IMPACTS - MULTI-USE TRAIL

U:\15431A\GIS\MXDs\equestrian_trail_072607.mxd

Exhibit Date: August 1, 2007

REC JN: 15431-A

0 100 200 400 Feet

Data Sources:
SanGIS Assessor Parcels: April 2006
SanGIS Roads - February 2006
Landiscor Aerial Photo: January 2006

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FIGURE 10-3.2

HABITAT IMPACTS - MULTI-USE TRAIL

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Exhibit Date: August 1, 2007
REC JN: 15431-A

Table 10-2. Permanent and Temporary Impacts to Existing Habitats

		Impacted Area - Multi-Use Trail (Acres)		
Habitat_ID	**Existing Habitat Description**	**Permanent Impacts (Footprint)**	**Temporary Impacts (5' Buffer)**	**Total Impacts (FP + Buffer)**
BM	Coastal Brackish Marsh	0.031	0.016	0.047
DIST	Disturbed	0.640	0.286	0.926
DMFS	Disturbed Mule-fat Scrub	0.000	0.0003	0.0003
DSM	Disturbed Southern Coastal Salt Marsh	1.550	0.592	2.142
DUPLAND	Disturbed Upland Habitat	0.616	0.241	0.857
MFS	Mule-fat Scrub	0.052	0.024	0.076
RUD	Ruderal	0.310	0.105	0.415
SF	Southern Foredunes	0.101	0.035	0.136
SM	Southern Coastal Salt Marsh	0.163	0.104	0.268
	Total (acres) =	**3.46**	**1.40**	**4.86**

Table 10-3. Restoration Area Habitat Impacts – Multi-Use Trail

	Impacted Area - Mulit-Use Trail (Acres)		
Restoration Habitat Description	**Permanent Impacts (Footprint)**	**Temporary Impacts (5' Buffer)**	**Total Impacts (FP + Buffer)**
Low Marsh	0.077	0.068	0.145
Mid-High Marsh	2.620	0.977	3.597
Mud Flat	0.010	0.007	0.017
Sub Tidal	0.051	0.021	0.072
Total =	**2.76**	**1.07**	**3.83**

10.4.2 Spooner's Mesa Alternative

The Proposed Spooner's Mesa route would begin at Monument Road directly across from the newly constructed sediment retention basins at the mouth of Goat Canyon (Figure 10-4). From that point, trail users would travel across the sediment retention basins on a path leading south. This route would then take users up onto Spooner's Mesa using existing trails to a point near the international border. The trail would then turn west and descend from the mesa to reach Monument Road where users would follow the existing road and a short connecting trail to the beach. This alternate route avoids potential traffic on much of Monument Road and offers outstanding views from the mesa top.

FIGURE 10-4 **Proposed Alternative Recreation Trail Alignments**

The Spooner's Mesa alternative would require little in terms of trail construction. Unpaved roads exist along the route that would be utilized for hiking, cycling and horseback riding. Access would be limited during wet weather. In addition, much of this route is currently used by the Border Patrol and could pose problems with high volumes of users. Furthermore, the border fence project, an approved double fence project along the Mexico/U.S border, would prohibit construction of portions of this alternative.

10.4.3 Monument Road Alternative

A second alternate trail route would begin at the same juncture with Monument Road. However, this route would follow Monument Road first west, then south, and then west again toward the beach area. This route is only marginally longer (approximately 1,000 feet) than the route eliminated by the restoration. It also takes advantage of the existing wide road surface and avoids any strenuous grade changes between the origin trail and the beach (Figure 10-4). However, this route does place equestrians, as well as hikers and potentially bicyclists, near automobile traffic on Monument Road. If this alternative is selected, it is proposed that some type of visual barrier be erected on the final north-south and east-west segments to shield other users from vehicles.

Construction of the Monument Road alternative would impact areas previously impacted by sediment deposition and fresh water. These areas were formerly dominated by high salt marsh and salt panne, but have been degraded as described in Section 2.4.

11.0 MATERIAL DISPOSAL OPTIONS

This section introduces potential sites for the disposal of sediments excavated during construction of the preferred restoration alternative (Figure 11-1). It was prepared by Rick Engineering Company (Rick), has been edited by Tierra, and is presented in its entirety.

The potential environmental impacts resulting from excavated material disposal may be physical, chemical or biological in nature. Given the location of the Tijuana Estuary project, initial testing results show metals and other organic contaminants, such as elevated levels of DDT (refer to Section 8.0 Substrate Characteristics). Proper management of excavation and disposal of contaminated sediments are required to protect water quality and aquatic or terrestrial organisms.

Review of the initial sediment testing results indicates that some of the material may be suited for beach nourishment. The remaining sediment will need to be disposed of at a suitable location which may include ocean disposal at LA-5, an upland location, or, if contaminated with DDT, at an approved landfill. The upland locations currently under consideration include the construction of a protective berm along the northwestern perimeter of the project, disposal at an inactive sand/gravel quarry, disposal at a landfill, or an alternative disposal site yet to be determined.

Beach Replenishment

The beneficial use of excavated material, including beach replenishment, was identified as a project goal (Section 3.0 Restoration Goals). Thus, the potential for using excavated and dredged materials for beach replenishment was evaluated. Beach replenishment would result in shoreline protection and additional beach area for recreation purposes.

Sediment characterization studies conducted by AMEC Earth & Environmental, Inc. (Section 8.0 Substrate Characterization), were reviewed and evaluated for sand appropriate for beach replenishment. The sampling studies and grain size analysis are included in reports in Appendices C and D.

Clean Water Act (CWA) Section 404 and 401 permit/certifications are required when dredged material is disposed of in either an aquatic or nearshore environment. These are also required when dredged material will be hydraulically placed in an upland environment and effluent from the disposal will be returned to waters of the U.S.

On-Site Confined Disposal

The use of excavated materials to construct a berm to protect the restored wetlands from flooding and sedimentation from the Tijuana River minimizes the time and costs associated with transporting the material off-site. The placement of excavated materials in such a manner will require the review and approval by the U. S. Army Corps of Engineers (USACE), U. S. Fish and Wildlife Service (USFWS), California Department of Fish and Game (CDFG), San Diego Regional Water Quality Control Board (RWQCB), the City of San Diego, California State Parks, and the California Coastal Commission. Permits required may include a USACE 404 permit,

FIGURE 11-1 **Alternative B (Preferred) Restoration Plan and Habitat Configurations**

and a RWQCB 401 certification, a CDFG Streambed Alteration Agreement, a California Coastal Commission coastal development permit, and a California State Parks right of entry permit.

Off-Site Confined Disposal

Opportunities for off-site disposal of excavated materials include: 1) transporting materials to a landfill, 2) selling aggregate to a materials company, and 3) filling existing quarry sites in the County of San Diego.

Transporting material to a landfill is the least desirable alternative because of costs and disposal site availability. The cost for the landfill alternative varies according to the distance from the project and fees associated with disposal of material. In addition, the availability of space at existing landfills and mining sites will need to be reevaluated when project funding becomes available.

The option of selling material to local materials companies is consistent with the disposal of materials deposited in the Goat Canyon sediment basins. A materials supplier has been screening sediment deposited in Goat Canyon and along Monument Road for several years. The size and composition of the material would determine whether or not it is considered a commodity.

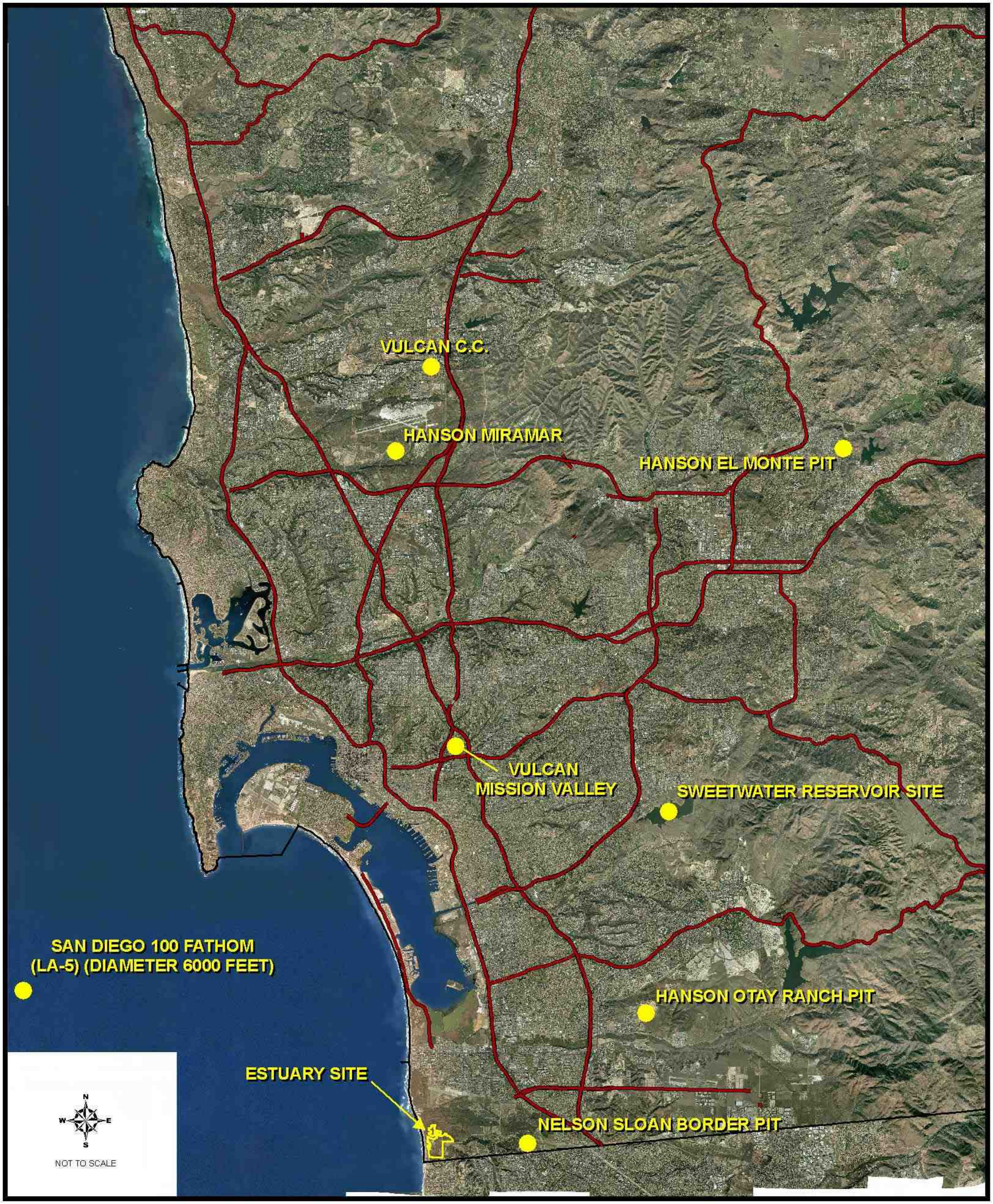
The option of transporting materials to an existing quarry site has constraints similar to transporting to a landfill, e.g., distance from the project and availability of space as funding becomes available. The following sites were evaluated as potential disposal sites:

1. Nelson Sloan Pit

The Nelson Sloan Pit is a mining site formerly operated by the Nelson & Sloan Company. This site is located approximately 4 miles west of the Friendship Marsh Restoration Site, directly west of the International Wastewater Treatment Plant and adjacent to the border with Mexico (Figure 11-2)**.** The site was operated for many years as a source of low-grade construction aggregates and miscellaneous fill material. The last period of activity was in the early 1990s when approximately one million cubic yards of fill were provided for the International Wastewater Treatment Plant. Since that time, there have been no activities at this site and it is no longer used for aggregate production.

Conditions on this site include a relatively large cut slope along the western portion of the site with a large, nearly level, pad to the east. This site would appear to be an ideal receptor for fill material as the site is fully disturbed and has the capacity to receive approximately 1,000,000 cubic yards of fill. The close proximity of this site is of primary importance.

Constraints include the potential need to obtain a land use entitlement from the County of San Diego. Presumably, a grading plan could be processed to include backfilling, compaction, and revegetation of the final surface with native species. The sediments excavated to construct the model marsh were disposed of in a similar manner at the abandoned Fenton Quarry site located approximately one mile east of the model marsh.



RICK ENGINEERING COMPANY

FIGURE 11-2

Location of Potential Disposal Sites

2. Otay Ranch Pit

The Otay Ranch Pit continues to be a highly important aggregate production site (Figure 11.2) active since the late 1940s. This site holds vested mining rights (i.e., no permit is required for continued operation). However, virtually the entire site is involved with aggregate production, processing, stockpiling, and transportation of materials. Although this site offers abundant fill capacity (5,000,000 cubic yards) and is in relatively close proximity (10 miles) to the project site, the continuous nature of its operation all but eliminates its potential for utilization. (Figure 11-2).

3. Sweetwater Reservoir

The upper portion of the Sweetwater Reservoir was formerly operated as a sand extraction site and a number of open water ponds could be utilized for fill placement. The Sweetwater Authority operates this portion of the reservoir as a highly prized habitat for the least Bell's vireo and other riparian species. As part of this habitat management program, Sweetwater Authority is interested in backfilling the ponds with alluvial sediments such that the area can be restored to a natural riparian woodland. Recent conversations with the Sweetwater Authority indicate that they may be open to a proposal for accepting fill material that originated from river sediments.

Constraints for this site would include limitations on the time of year that fill materials can be received and placed. This site is also located at considerable distance (22 miles; Figure 11-2) from the project site, increasing the cost for transporting excavated material. The volume of material that the site is projected to receive is 1,000,000 cubic yards.

4. Vulcan Mission Valley

Vulcan Materials operates an aggregate production site approximately 21 miles from the project location, on the north side of Mission Valley just west of Interstate 805 (Figure 11-2). This site is nearing depletion and the need for fill at this site is unknown.

5. Hanson Aggregates Miramar Landfill

Hanson Aggregates operates a clean fill material landfill at their Miramar property on Harris Plant Road. This site is an inholding within MCAS Miramar, approximately 29 miles from the project location (Figure 11-2). Conversations with Hanson landfill staff indicate that approximately 500,000 cubic yards of fill volume remains at this location.

Although this site is located at considerable distance from the project site, its location close to I-15 and lack of conflict with surrounding land uses are beneficial factors. Constraints include the limited capacity of the land fill.

6. Vulcan Carroll Canyon

The Vulcan Carroll Canyon site is an active aggregate production site located about one mile west of the Carroll Canyon Road and I-15 interchange, approximately 30 miles from the project location (Figure 11-2). This site is nearing depletion, but has a fill capacity of approximately 500,000 cubic yards.

Although this site is located at considerable distance from the project site, its location close to I-15 is a beneficial factor. Other constraints include the limited capacity of the landfill.

7. Hanson Aggregates El Monte Sand Pit

Hanson Aggregates operates the El Monte Sand Pit near Lakeside approximately 35 miles from the project location (Figure 11-2). This site is nearing depletion, but will continue to operate for approximately 2-3 more years. Reclamation requirements include backfilling approximately half of the mine void with clean fill materials. Total volume of backfill required for this site is approximately 1,000,000 cubic yards.

Benefits of this site are its high capacity and relative ease of access. Constraints include the considerable distance from the project site.

Open-Water Disposal

Presently, open-water disposal must occur at a designated area. The closest designated site is LA-5 off the coast of Point Loma (Figure 11-2).

The EPA and USACE share responsibility for the regulation of ocean dumping of dredged materials under the marine protection, research, and sanctuaries act of 1972. Permits are issued by the USACE with EPA concurrence. These are discussed in greater detail later in this section.

Benefits of disposal at LA-5 include an unlimited area for disposal. Constraints of this type of disposal include the inherent difficulties of pumping dredged slurry to a barge offshore of Tijuana Estuary; the potential that DDT will render some of the material unsuitable for open ocean disposal; and the cost of transporting material to LA-5.

12.0 PROJECT PHASING AND CONSTRUCTION ALTERNATIVES ANALYSIS

This analysis was prepared by Rick Engineering and has been edited by Tierra. It is presented here in its entirety.

This programmatic-level feasibility and design study identifies phases or modules of the overall restoration project that would be constructed as funding becomes available. These phases are conceptual and are presented as a means of estimating project costs and determining project impacts. It is anticipated that these conceptual phases will be refined once funding for one or more phases becomes available. The analysis includes the potential impacts to sensitive resources and disposal alternatives proposed for each phase. The regulatory and jurisdictional framework associated with sediment disposal is addressed as they relate to the construction phasing alternatives and their associated costs and benefits.

12.1 Regulatory Framework

Dredged material disposal within the waters of the United States is regulated by four congressional acts: sections 102 and 103 of the Marine Protection, Research, and Sanctuaries Act (MPRSA); sections 401 and 404 of the Clean Water Act (CWA); section 10 of the Rivers and Harbors Act of 1899; and the National Environmental Protection Act (NEPA). Two entities jointly share responsibility for this dredged material disposal — the United States Environmental Protection Agency (EPA) and the United States Army Corps of Engineers (USACE). The geographical jurisdiction of the MPRSA and CWA extends from inland and estuarine waters, to the limit of U.S. territorial waters approximately 3 miles off the contiguous U.S. coastline.

In addition to federal regulation, compliance with State water quality standards requires the project to obtain California Environmental Quality Act (CEQA) approval. Other local government entities such as the California Regional Water Quality Control Board, the County of San Diego, and the City of San Diego also require permitting within their jurisdictions.

12.1.1 Project Management Alternatives

The Tijuana Estuary-Friendship Marsh Tidal Restoration Feasibility and Design project involves the conversion of a degraded portion of the existing estuary with low biological function into a dynamic estuarine system with high biological function. The restoration area is currently highly disturbed, with much of the area elevated above the level of adequate tidal inundation. For these and other reasons, the entire project area must be excavated to the appropriate levels and revegetated. With restored tidal inundation, this area will once again provide a diversity of estuarine habitats suitable for regionally rare flora and fauna.

The excavation of the entire project involves the removal and disposal of approximately 2.5 million cubic yards of material which presents a significant management challenge. Four major alternatives have been considered in various combinations for the disposal of excavated material. These include: 1) trucking material to various landfill/aggregate mine disposal sites in the County; 2) confined disposal which in this location involves using some of the material to create a protective berm; 3) open water disposal in the deep ocean via hopper dredge or barge, and; 4) beneficial use where excavated materials are used for local beach, and dune replenishment. Details regarding specific disposal methods, sites and management combinations are presented below.

12.2 Specific Construction Alternatives

Construction alternatives are divided into 5 categories (A through E) and each is applied to the 5 proposed conceptual phases of the restoration project. Each letter category generally represents a different approach to excavated material use and disposal. Many disposal sites exist that are potentially able to accept excavated materials. However, few sites close to the project site are likely to be available for material disposal.

Category A alternatives propose to truck most of the excavated material approximately 35 miles to the Hanson El Monte Pit in Lakeside. Generally, with the exception of berm creation in project Phase 1, Category A alternatives do not consider the use of excavated material for beneficial uses such as beach and dune replenishment.

Category B alternatives are similar to Category A, but attempt to maximize the volume of excavated material used for beneficial uses such as beach replenishment. This effort would reduce the volume and cost of trucking material to distant landfill sites.

Category C alternatives attempt to further maximize the volume of material used for beneficial uses by excavating below the finished project grades to access additional sands suitable for beach and dune replenishment. Category C alternatives also use a hydraulic dredge and pump-line rather than trucks alone to carry suitable sands to the beach zone. Materials not suitable for beneficial uses would be hauled by truck to the Hanson El Monte Pit in Lakeside.

Category D alternatives are generally similar to B alternatives except that materials not suitable for beneficial uses would be pumped to a barge and transported to a deep ocean disposal site (LA-5) off the coast of San Diego.

Category E alternatives are generally similar to A and B alternatives except that materials not suitable for beneficial uses would be trucked to a variety of open-pit aggregate mines that are closer (some only 4 miles) to the project site than the Hanson El Monte Pit.

12.2.1 Phase 1 Construction Alternatives

The proposed first phase of construction is located adjacent to Monument Road and southeast of the model marsh (Figures 12-1 to 12-5). These figures also show the configurations of proposed wetland habitat types to be created and the approximate elevations of those habitat types. The area of Phase 1 is approximately 39 acres. The volume of excavation required to attain the proposed elevations is approximately 571,000.

cubic yards. This volume consists of about 74,000 cubic yards of sands suitable for beach replenishment and 497,000 cubic yards of material to be disposed of at other locations. All Phase 1 alternatives would use 30,000 cubic yards of material for the construction of a protective berm between the main channel of the Tijuana River and the project site. This berm will be armored with riprap on the flank facing the river to protect against flood erosion. Some of the material excavated during construction will require handling of wet materials which will occur on-site, on disturbed ground. The following are descriptions of the various alternatives for the disposal of material excavated in Phase 1.

Alternative 1A (Figure 12-1) involves the removal of 571 cubic yards of material with conventional scrapers and drag-line. Approximately 30,000 cubic yards of excavated fine material would be hauled by trucks on existing trails to create the protective berm between the project site and the effective flow of the Tijuana River. The remaining 541,000 cubic yards of material would be hauled by truck approximately 35 miles to Hanson El Monte Pit in Lakeside. Costs associated with this alternative are detailed in Table 12-1.

Table 12-1. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 1A

Item	Quantity	Unit	Unit Price	Cost
Mobilization	1	LS	$20,000.00	$20,000
Clearing & Grubbing	39	Ac	$1,500.00	$58,500
Erosion Control	39	Ac	$9,000.00	$351,000
Excavation (Scraper)	507,000	CY	$2.00	$1,014,000
Excavation (Dragline)	64,000	CY	$6.00	$384,000
Export to Berm	30,000	CY	$1.50	$45,000
Export to Landfill	541,000	CY	$28.00	$15,148,000
Handling Wet Material	64,000	CY	$10.00	$640,000
Slope Protection for Berm	13,000	CY	$200.00	$2,600,000
Disposal Fees	541,000	CY	$5.00	$2,705,000
Dust Control	1	LS	$200,000.00	$200,000
Cleanup	1	LS	$100,000.00	$100,000
Finish Grading	39	Ac	$8,000.00	$312,000
Access Road Maintenance	101,000	SF	$3.00	$303,000
			Subtotal:	$23,880,500
			15% Contingency:	$3,582,075
			Design & Indirect Cost (21.5%):	$5,134,308
			Total Construction Budget:	***$32,596,883***

Table l2-1. Continued

Design & Indirect Costs Breakdown		
Design		
	Civil Engineer	5.0%
	Landscape Architect	2.5%
	Geotechnical Engineer	0.5%
Indirect		
	Construction Staking	0.5%
	Permits	0.5%
	Bonds	1.0%
	Insurance (Prime)	1.8%
	Main Office Expense (Prime)	3.9%
	Scheduling	0.1%
	Field Office, Photos	0.7%
	Field Testing	1.0%
	Field Supervision	2.9%
	Mitigation Monitoring	1.5%
		21.50%

Habitat and Plantings	Area (Acres)	Quantity	Unit	Unit Price	Cost
SUBTIDAL	22.9				
No planting					
MUDFLAT	6.1				
No planting					
LOW MARSH	4.1				
Transplants, 6' o.c.		8,249	each	$13.50	$111,361.50
MID/HIGH MARSH	3.1				0
Rosepots, 6' o.c.		4,331	each	$4.00	$17,323.00
TRANSITION	2.5				
Rosepots, 6' o.c.		3,493	each	$4.00	$13,972.00
Large rotor irrigation system		108,900	sq. ft.	$0.75	$81,675.00
Hydroseeding		108,900	sq. ft.	$0.15	$16,335.00
Weed prior to planting		108,900	sq. ft.	$0.02	$2,178.00
				Total Planting Budget:	$242,844.50
				Total Construction Budget:	$32,596,883.00
				Total Alternative 1A:	***$32,839,727***

Legend

	Elevation of Habitat Region	Area (acres)
Subtidal	-2'	22.9
Mudflat	0'	6.1
Low Marsh	1.5'	4.1
Mid-High Marsh	2.2'	3.1
Transition Zone	4.5' - 5'	2.5

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FIGURE 12-1

Alternative 1A

N W E S

1 inch equals 800 feet

0 200 400 800

Alternative 1B (Figure 12-2) involves the removal of material in the same general manner as Alternative 1A. However, in this alternative 74,000 cubic yards of excavated sands suitable for beach replenishment would be hauled by trucks to the Beach Replenishment Zone and distributed between the existing dunes and the surf zone. An additional 30,000 cubic yards of fine material would also be hauled by trucks on existing trails to create the protective berm between the project site and the effective flow of the Tijuana River. The remaining 467,000 cubic yards of material would be hauled by truck along Monument Road to the Hanson El Monte Pit in Lakeside. Costs associated with this alternative are detailed in Table 12-2.

Table 12-2. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 1B

Item	Quantity	Unit	Unit Price	Cost
Mobilization	1	LS	$25,000.00	$25,000
Clearing & Grubbing	39	Ac	$1,500.00	$58,500
Erosion Control	39	Ac	$9,000.00	$351,000
Excavation (Scraper)	507,000	CY	$2.00	$1,014,000
**				
Excavation (Dragline)	64,000	CY	$6.00	$384,000
Export & Placement in Berm	30,000	CY	$1.50	$45,000
Wet Handling Materials	64,000	CY	$10.00	$640,000
Slope Protection for Berm	13,000	CY	$200.00	$2,600,000
Export to Landfill	467,000	CY	$28.00	$13,076,000
Export to Beach	74,000	CY	$1.50	$111,000
Disposal Fees	467,000	CY	$5.00	$2,335,000
Dust Control	1	LS	$225,000.00	$225,000
Cleanup	1	LS	$100,000.00	$100,000
Finish Grading	39	Ac	$8,000.00	$312,000
Access Road Maintenance	131,000	SF	$3.00	$393,000
			Subtotal:	$21,669,500
			15% Contingency:	$3,250,425
			**Design and Indirect Costs:*	$4,658,943
			Total Construction Budget:	$29,578,868
			**Total Planting Budget:*	$242,844.50
			Total Alternative 1B:	***$29,821,713***

*See Table 12-1 for breakdown of indirect and planting costs.

Legend

	Elevation of Habitat Region	Area (acres)
Subtidal	-2'	22.9
Mudflat	0'	6.1
Low Marsh	1.5'	4.1
Mid-High Marsh	2.2'	3.1
Transition Zone	4.5' - 5'	2.5

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FIGURE 12-2

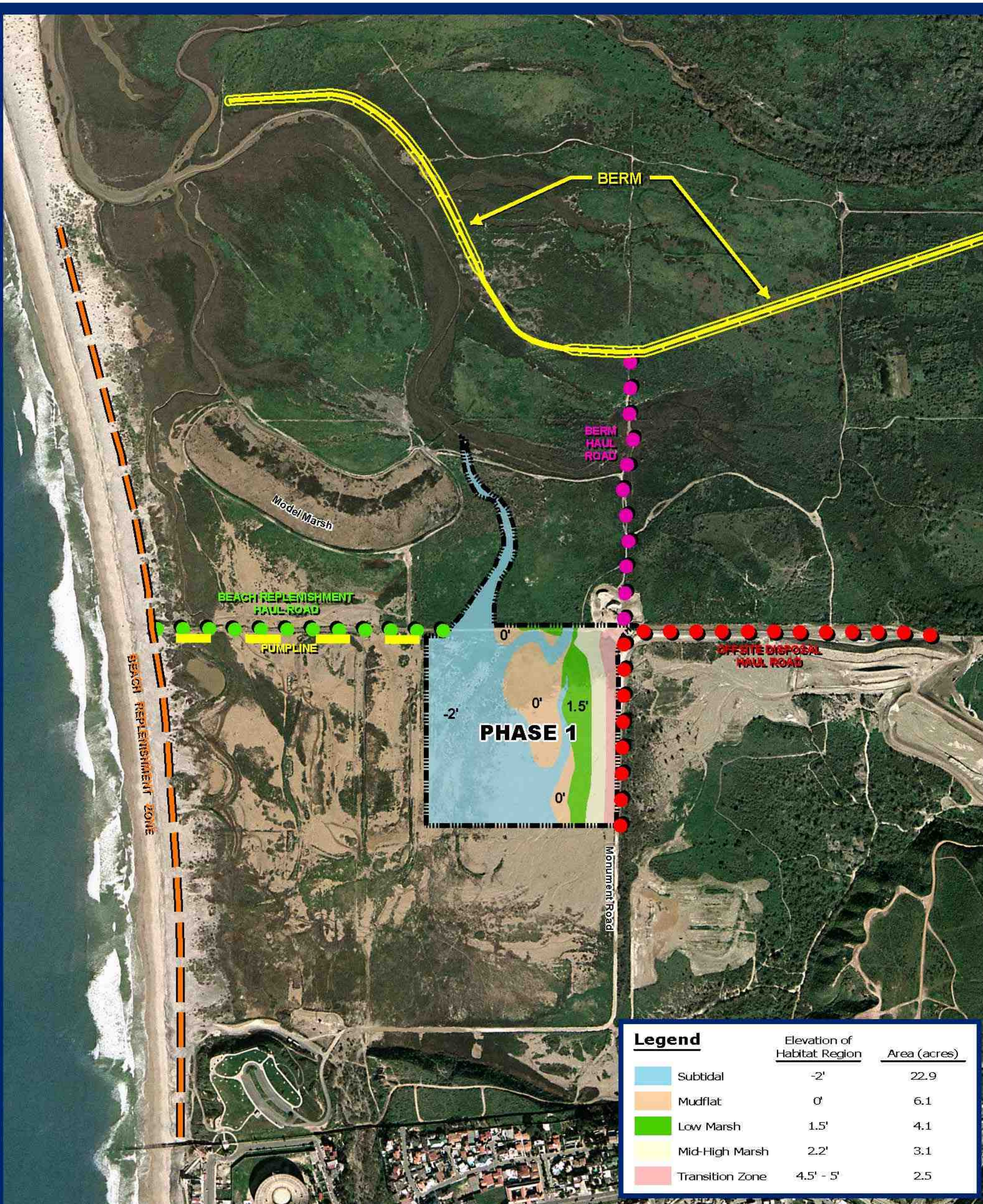
Alternative 1B

Alternative 1C (Figure 12-3) proposes to minimize trucking material offsite by excavating below the proposed finished grades. This method would produce 213,000 cubic yards of deeply dredged sands and 74,000 cubic yards of surface sands suitable for beach replenishment. The 213,000 cubic yards would be pumped to the beach and the 74,000 cubic yards would be trucked to the beach. Sands suitable for beach replenishment would be distributed between the existing dunes and the surf zone. The void formed by removal of these sands would be replaced with material that would normally have been hauled offsite. An additional 30,000 cubic yards of fine material would be hauled by trucks on existing trails to create the protective berm. The remaining 254,000 cubic yards of material would be hauled by truck along Monument Road to the Hanson El Monte Pit in Lakeside. Costs associated with this alternative are detailed in Table 12-3.

Table 12-3. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 1C

Item	Quantity	Unit	Unit Price	Cost
Mobilization	1	LS	$35,000.00	$35,000
Clearing & Grubbing	39	Ac	$1,500.00	$58,500
Erosion Control	39	Ac	$9,000.00	$351,000
Excavation (Scraper)	507,000	CY	$2.00	$1,014,000
Excavation (Dragline)	64,000	CY	$6.00	$384,000
Excavation (Hydraulic Dredge)	213,000	CY	$10.00	$2,130,000
Export to Beach (Pumpline)	213,000	CY	$5.00	$1,065,000
Export to Beach (Scraper)	74,000	CY	$1.50	$111,000
Export to Landfill	254,000	CY	$28.00	$7,112,000
Export & Placement in Berm	30,000	CY	$1.50	$45,000
Wet/Special Handling Material	64,000	CY	$10.00	$640,000
Slope Protection for Berm	13,000	CY	$200.00	$2,600,000
Disposal Fees	254,000	CY	$5.00	$1,270,000
Dust Control	1	LS	$225,000.00	$225,000
Cleanup	1	LS	$100,000.00	$100,000
Finish Grading	39	Ac	$8,000.00	$312,000
Access Road Maintenance	131,000	SF	$3.00	$393,000
			Subtotal:	$17,845,500
			15% Contingency:	$2,676,825
			**Design & Indirect Costs (21.5%):*	$3,836,783
			Total Construction Budget:	$24,359,108
			**Total Planting Budget:*	$244,844.50
			Total Alternative 1C:	***$24,601,953***

*See Table 12-1 for breakdown of indirect and planting costs.



Legend	Elevation of Habitat Region	Area (acres)
Subtidal	-2'	22.9
Mudflat	0'	6.1
Low Marsh	1.5'	4.1
Mid-High Marsh	2.2'	3.1
Transition Zone	4.5' - 5'	2.5

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FIGURE 12-3

Alternative 1C

N W E S

1 inch equals 800 feet

0 200 400 800

Alternative 1D (Figure 12-4) employs a different strategy to minimize hauling material offsite by truck. First, approximately 74,000 cubic yards of surface sands would be hauled to the Beach Replenishment Zone where it would be distributed between the existing dunes and the surf zone. An additional 30,000 cubic yards of fine material would be hauled by trucks on existing trails to create the protective berm. The remaining 467,000 cubic yards of material would be removed with a hydraulic dredge, pumped to a barge, and taken to the LA-5 deep ocean disposal site off the coast of San Diego (Figure 11-2). Costs associated with this alternative are detailed in Table 12-4.

Table 12-4. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 1D

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$50,000.00	$50,000
Clearing & Grubbing	39	Ac	$1,500.00	$58,500
Erosion Control	39	Ac	$9,000.00	$351,000
Excavation (Dredge)	507,000	CY	$10.00	$5,070,000
Excavation (Dragline)	64,000	CY	$6.00	$384,000
Export & Placement for Berm	30,000	CY	$1.50	$45,000
Slope Protection for Berm	13,000	CY	$200.00	$2,600,000
Export to Beach (Scraper)	74,000	CY	$1.50	$111,000
Pump to Scow	467,000	CY	$10.00	$4,670,000
Tow Scow to LA-5	467,000	CY	$10.00	$4,670,000
Disposal Fees	467,000	CY	$5.00	$2,335,000
Dust Control	1	LS	$225,000.00	$225,000
Cleanup	1	LS	$180,000.00	$180,000
Finish Grading	39	Ac	$8,000.00	$312,000
Access Road Maintenance	131,000	SF	$3.00	$393,000
			Subtotal:	$21,454,500
			15% Contingency:	$3,218,175
			**Design & Indirect Costs (21.5%):*	$4,612,718
			Total Construction Budget:	$29,285,393
			**Total Planting Budget:*	$242,844.50
			Total Alternative 1D:	***$29,428,238***

*See Table 12-1 for breakdown of indirect and planting costs.

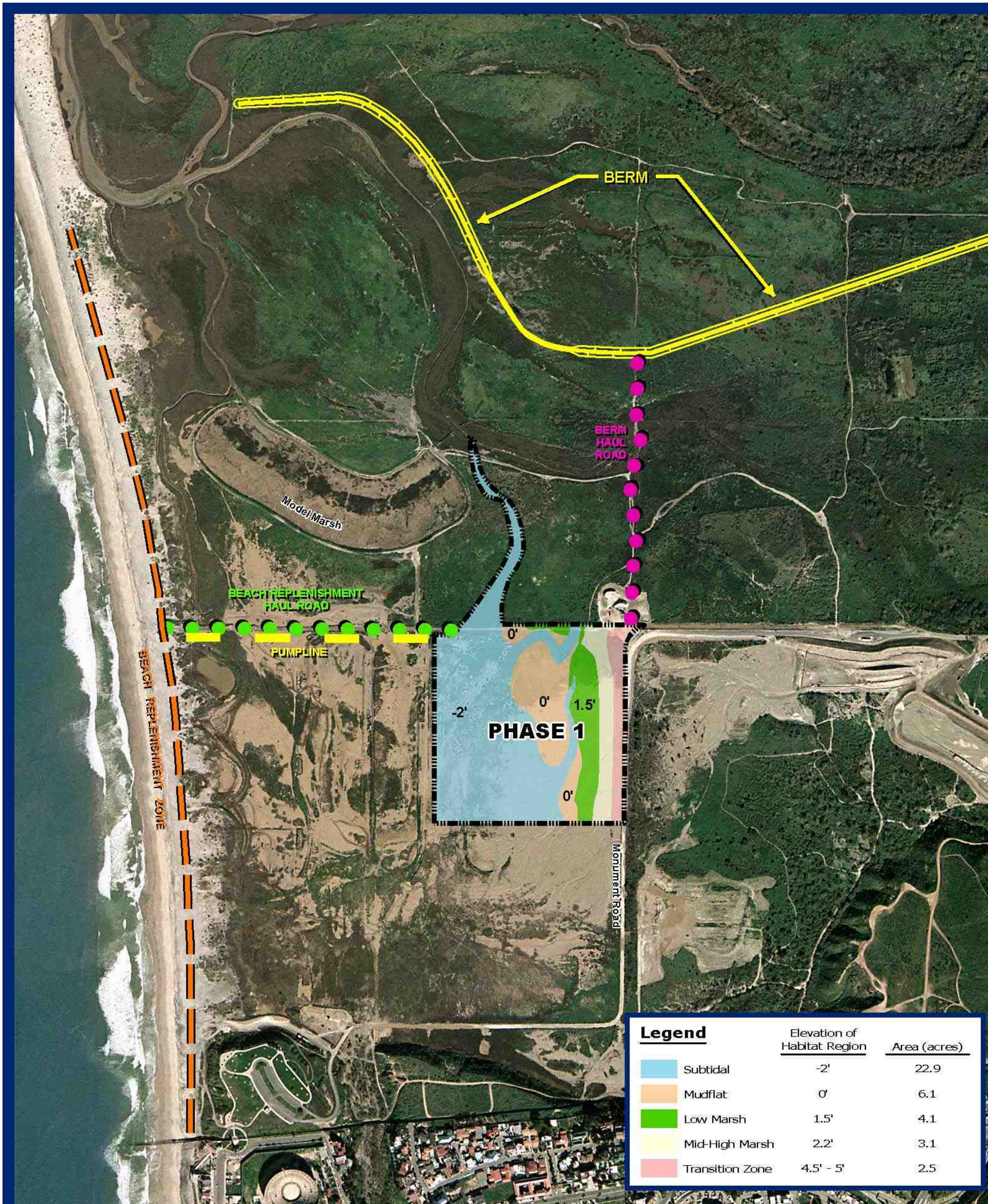

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FIGURE 12-4

Alternative 1D

N W E S

1 inch equals 800 feet

0 200 400 800

Alternative 1E (Figure 12-5) involves the removal of excavated material, berm construction, and beach replenishment in the same manner as Alternative 1B. However, the remaining 467,000 cubic yards of material not suitable for beach replenishment or berm construction would be taken to a closer alternate disposal site, the Nelson/Sloan Pit at Dairy Mart Road, approximately 4 miles from the project site (Figure 11-2). This site is inactive, not yet reclaimed, and may be available for disposal. Costs associated with this alternative are detailed in Table 12-5.

Phase 1 would create a total of 39 acres of southern coastal salt marsh habitat with 22.9 acres of tidal lagoon/open water, 6.1 acres of mudflat, 4.1 acres of low salt marsh, 3.1 acres of mid-high salt marsh and 2.5 acres of upland transitional habitat. The construction of Phase 1 is considered self-mitigating; impacts and mitigation associated with this phase are discussed further in Section 12.4.

Table 12-5. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 1E

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$20,000.00	$20,000
Clearing & Grubbing	39	Ac	$1,500.00	$58,500
Erosion Control	39	Ac	$9,000.00	$351,000
Excavation (Scraper)	507,000	CY	$2.00	$1,014,000
Excavation (Dragline)	64,000	CY	$6.00	$384,000
Export & Placement for Berm	30,000	CY	$1.50	$45,000
Handling Wet Material	64,000	CY	$10.00	$640,000
Slope Protection for Berm	13,000	CY	$200.00	$2,600,000
Export to Beach	74,000	CY	$1.50	$111,000
Export to Local Disposal Site	467,000	CY	$2.50	$1,167,500
Disposal Fees	467,000	LS	$5.00	$2,335,000
Dust Control	1	LS	$225,000.00	$225,000
Cleanup	1	LS	$100,000.00	$100,000
Finish Grading	39	Ac	$8,000.00	$312,000
Access Road Maintenance	131,000	SF	$3.00	$393,000
			Subtotal:	$9,756,000
			15% Contingency:	$1,463,400
			**Design & Indirect Costs (21.5%):*	$2,097,540.00
			Total Construction Budget:	$13,316,940.00
			**Total Planting Budget:*	$242,844.50
			Total Alternative 1E:	***$13,559,785***

*See Table 12-1 for breakdown of indirect and planting costs.

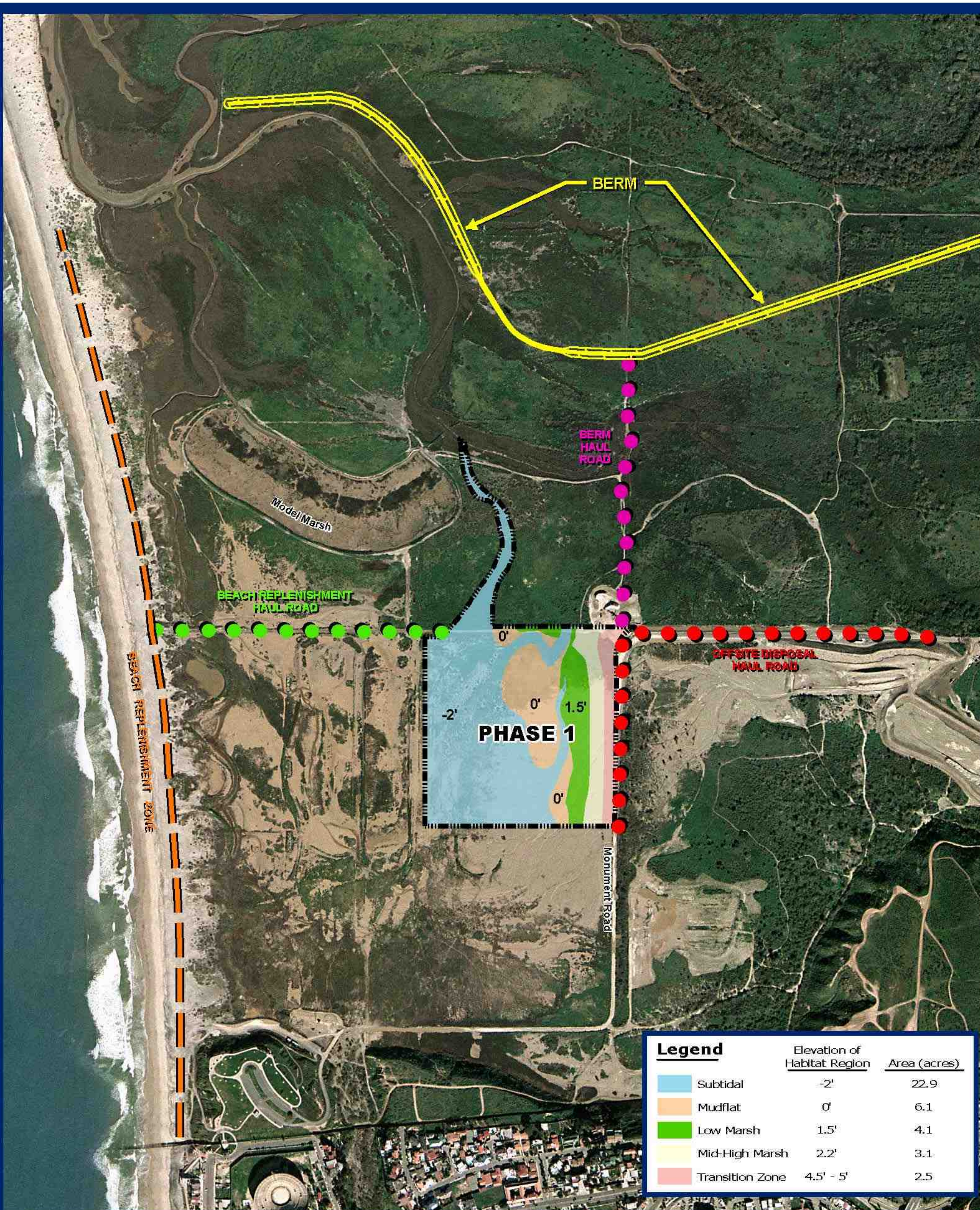

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FIGURE 12-5

Alternative 1E

N W E S

1 inch equals 800 feet

0 200 400 800

12.2.2 Phase Two Construction Alternatives

Phase 2 is located north of Phase 1 and adjacent to the model marsh (Figures 12-6 to 12-10). These figures also show the configurations of proposed habitat types and the approximate elevations of those habitat types. Phase 2 consists of two distinct areas totaling approximately 37 acres. The volume of excavation required to attain the proposed elevations is 319,000 cubic yards. Unfortunately, this volume consists of very few sands with characteristics suitable for beach replenishment. Some of the excavated material will require wet-handling which will occur onsite, on disturbed ground. The following are descriptions of various alternatives for the disposal of material in Phase 2.

Alternative 2A (Figure 12-6) involves the removal of approximately 319,000 cubic yards material with conventional scrapers and drag line. All of the excavated material would be loaded on to trucks, hauled on existing trails to Monument Road and then taken approximately 35 miles to El Monte Pit in Lakeside (Figure 11-2). Costs associated with this alternative are detailed in Table 12-6.

Table 12-6. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 2A

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$20,000	$20,000
Clearing & Grubbing	37	Ac	$1,500	$55,500
Erosion Control	37	Ac	$9,000	$333,000
Excavation (Scraper)	263,000	CY	$2	$526,000
Excavation (Dragline)	56,000	CY	$6	$336,000
Export to Landfill	319,000	CY	$28	$8,932,000
Disposal Fees	319,000	CY	$5	$1,595,000
Handling Wet Material	56,000	CY	$10	$560,000
Dust Control	1	LS	$200,000	$200,000
Cleanup	1	LS	$100,000	$100,000
Finish Grading	37	Ac	$8,000	$296,000
Road Maintenance	179,000	SF	$3	$537,000
			Subtotal:	$13,490,500
			15% Contingency:	$2,023,575
			Design & Indirect Cost (21.5%):	$2,900,457.50
			Total Construction Budget:	***$18,414,532.50***

Table 12-6. Continued

Habitat and Plantings	Area (Acres)	Quantity	Unit	Unit Cost	Cost
SUBTIDAL	7.7				
No planting					
MUDFLAT	6.1				
No planting					
LOW MARSH	10.8				
Transplants, 6' o.c.		21,730	Each	$13.50	$293,355
MID/HIGH MARSH	12.7				
Rosepots, 6' o.c.		17,743	Each	$4.00	$70,970
TRANSITION	0				
Rosepots, 6' o.c.					
				Total Planting Budget:	$364,325
				Total Construction Budget:	$18,414,533
				Total Alternative 2A:	***$18,778,855***

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FIGURE 12-6

Alternative 2A

N W E S
1 inch equals 800 feet
0 200 400 800

Alternative 2B (Figure 12-7) involves the removal of material in the same general manner as Alternative 2A. However, in this alternative 10,000 cubic yards of excavated sands suitable for dune enhancement would be hauled by trucks on existing trails to the Beach Replenishment Zone and distributed between the existing dunes and the surf zone. The remaining 309,000 cubic yards of material would be hauled on existing trails to Monument Road and then taken to the Hanson El Monte Pit in Lakeside. Costs associated with this alternative are detailed in Table 12-7.

Table 12-7. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 2B

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$20,000.00	$20,000
Clearing & Grubbing	37	Ac	$1,500.00	$55,500
Erosion Control	37	Ac	$9,000.00	$333,000
Excavation (Scraper)	263,000	CY	$2.00	$526,000
Excavation (Dragline)	56,000	CY	$6.00	$336,000
Export to Beach (Scraper)	10,000	CY	$1.50	$15,000
Export to Landfill	309,000	CY	$28.00	$8,652,000
Disposal Fees	309,000	CY	$5.00	$1,545,000
Handling Wet Material	56,000	CY	$10.00	$560,000
Dust Control	1	LS	$200,000.00	$200,000
Cleanup	1	LS	$100,000.00	$100,000
Finish Grading	37	Ac	$8,000.00	$296,000
Access Road Maintenance	204,000	SF	$3.00	$612,000
			Subtotal:	$13,250,500
			15% Contingency:	$1,987,575
			**Design & Indirect Costs (21.5%):*	$2,848,857.50
			Total Construction budget:	$18,086,932.50
			**Total Planting Budget*:	$364,325
			Total Alternative 2B:	***$18,451,258***

*See Table 12-6 for breakdown of indirect and planting costs.

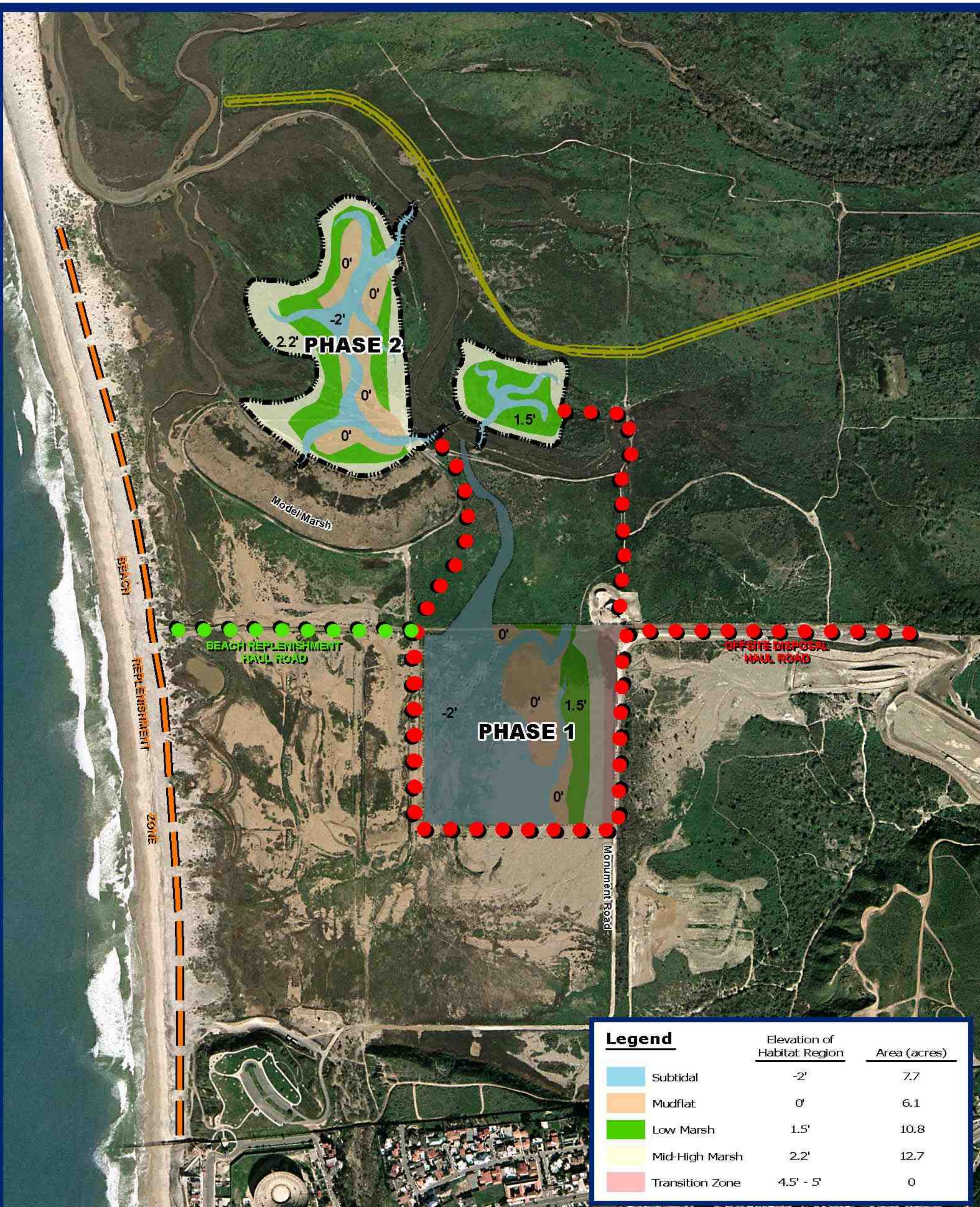

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FIGURE 12-7

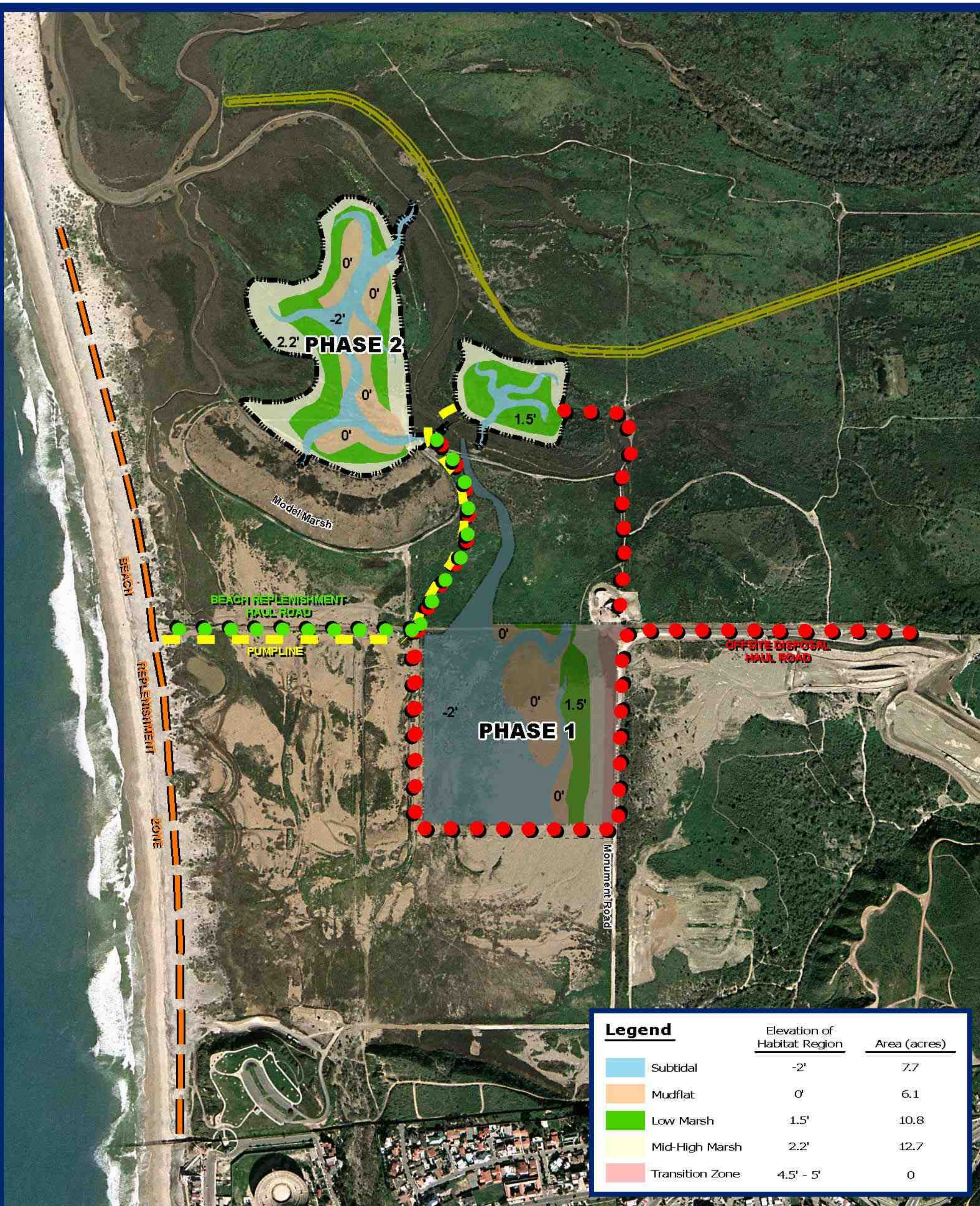
Alternative 2B

Alternative 2C (Figure 12-8) proposes to minimize trucking material offsite by excavating below the proposed finished grades. This method would produce 240,000 cubic yards of deeply dredged sands suitable for beach replenishment. These sands would be pumped to the beach and distributed between the existing dunes and the surf zone. An additional 10,000 cubic yards of excavated sands suitable for dune enhancement would be hauled by trucks on existing trails to the Beach Replenishment Zone and distributed between the existing dunes and the surf zone. The void formed by removal of these sands would be replaced with material that would normally have been hauled offsite. The remaining 69,000 cubic yards of material would be hauled along Monument Road and then taken to the Hanson El Monte Pit in Lakeside. Costs associated with this alternative are detailed in Table 12-8.

Table 12-8. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 2C

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$35,000.00	$35,000
Clearing & Grubbing	37	Ac	$1,500.00	$55,500
Erosion Control	37	Ac	$9,000.00	$333,000
Excavation (Scraper)	263,000	CY	$2.00	$526,000
Excavation (Hydraulic Dredge)	400,000	CY	$10.00	$4,000,000
Excavation (Dragline)	56,000	CY	$6.00	$336,000
Export to Beach (Scraper)	10,000	CY	$1.50	$15,000
Export to Beach (Pumpline)	240,000	CY	$5.00	$1,200,000
Export to Landfill	69,000	CY	$28.00	$1,932,000
Disposal Fees	69,000	CY	$5.00	$345,000
Handling Wet Material	216,000	CY	$10.00	$2,160,000
Dust Control	1	LS	225,000.00	$225,000
Cleanup	1	LS	$100,000.00	$100,000
Finish Grading	37	Ac	$8,000.00	$296,000
Access Road Maintenance	204,000	SF	$3.00	$612,000
			Subtotal:	$12,170,500
			15% Contingency:	$1,825,575
			**Design & Indirect Costs (21.5%):*	$2,616,657.50
			Total Construction Budget:	$16,612,732.50
			**Total Planting Budget:*	$346,325
			Total Alternative 2C:	***$16,977,058***

*See Table 12-6 for breakdown of indirect and planting costs.



Legend

	Elevation of Habitat Region	Area (acres)
Subtidal	-2'	7.7
Mudflat	0'	6.1
Low Marsh	1.5'	10.8
Mid-High Marsh	2.2'	12.7
Transition Zone	4.5' - 5'	0

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FIGURE 12-8

Alternative 2C

Alternative 2D (Figure 12-9) employs a different strategy to minimize hauling material offsite by truck. First, approximately, 10,000 cubic yards of excavated material suitable for dune enhancement would be hauled by trucks on existing trails to the Beach Replenishment Zone and distributed between the existing dunes and the surf zone. The remaining 309,000 cubic yards of material would be removed with a hydraulic dredge, pumped to a barge and taken to LA-5 off the coast of San Diego (Figure 11-2). Costs associated with this alternative are detailed in Table 12-9.

Table 12-9. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 2D

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$50,000.00	$50,000
Clearing & Grubbing	37	Ac	$1,500.00	$55,500
Erosion Control	37	Ac	$9,000.00	$333,000
Excavation (Hydraulic Dredge)	319,000	CY	$10.00	$3,190,000
Export to Beach (Pumpline)	10,000	CY	$5.00	$50,000
Pump to Scow	309,000	CY	$10.00	$3,090,000
Tow Scow to LA-5	309,000	CY	$10.00	$3,090,000
Disposal Fees	309,000	CY	$5.00	$1,545,000
Dust Control	1	LS	$225,000.00	$225,000
Cleanup	1	LS	$180,000.00	$180,000
Finish Grading	37	Ac	$8,000.00	$296,000
Access Road Maintenance	45,000	SF	$3.00	$135,000
			Subtotal:	$12,239,500
			15% Contingency:	$1,835,925
			**Design & Indirect Costs (21.5%):*	$2,631,493
			Total Construction Budget:	$16,706,918
			**Total Planting Budget:*	$364,325
			Total Alternative2D:	***$17,071,243***

*See Table 12-6 for breakdown of indirect and planting costs.

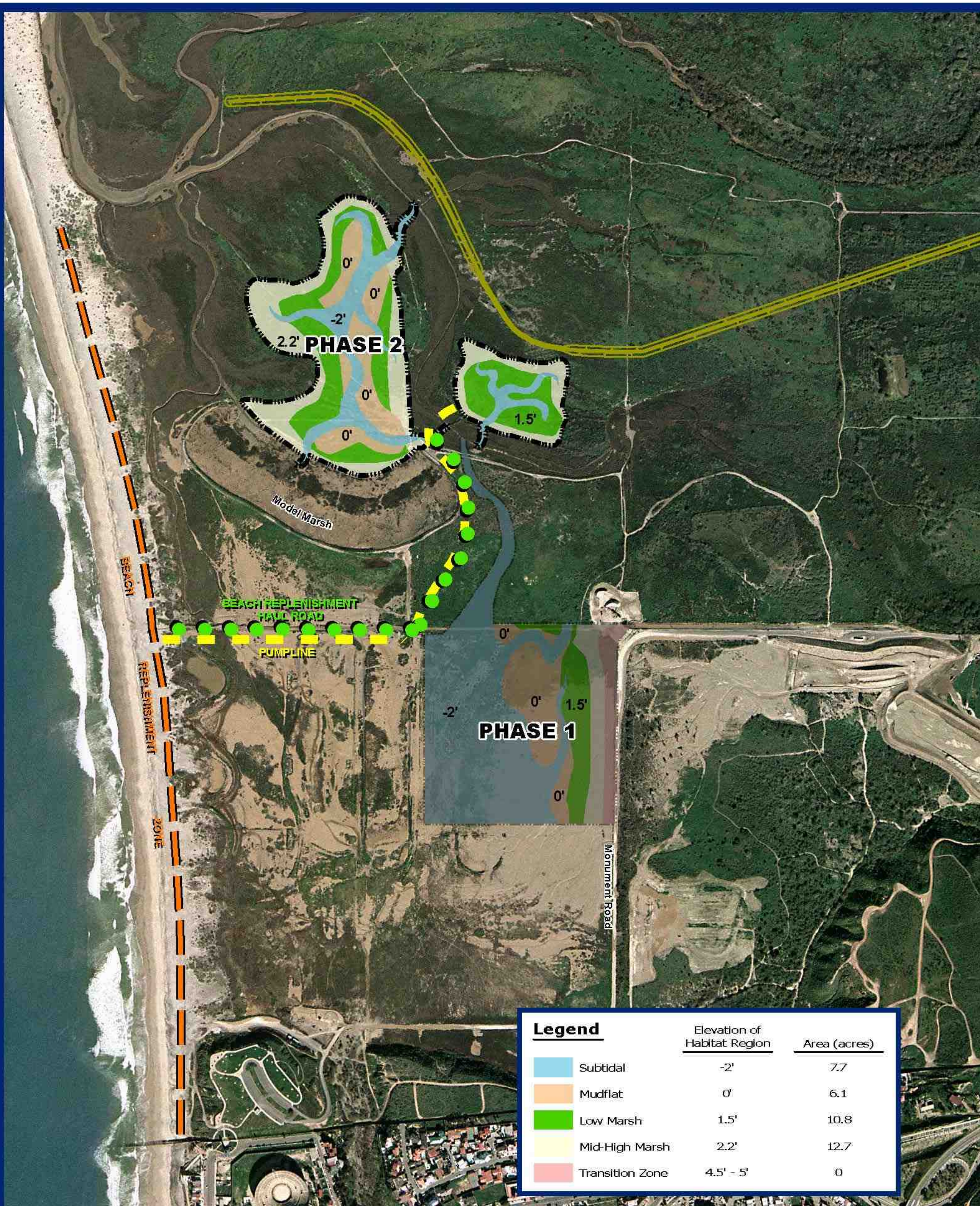

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FIGURE 12-9

Alternative 2D

Alternative 2E (Figure 12-10) involves the removal of material and dune replenishment in the same manner as Alternative 2B. However, the remaining 309,000 cubic yards of material not suitable for dune enhancement would be taken to a closer alternate disposal site, the Nelson Sloan Pit at Dairy Mart Road, approximately 4 miles from the project site (Figure 11-2). This site is inactive, not yet reclaimed, and may be available for disposal. Costs associated with this alternative are detailed in Table 12-10.

Phase 2 would create 37.3 acres of wetland habitat with 7.7 acres of tidal lagoon/open water, 6.1 acres of mudflat, 10.8 acres of low salt marsh, and 12.7 acres of mid-high salt marsh. Potential environmental impacts and mitigation associated with this phase are presented in detail in Section 12.4.

Table 12-10. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 2E

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$20,000.00	$20,000
Clearing & Grubbing	37	Ac	$1,500.00	$55,500
Erosion Control	37	Ac	$9,000.00	$333,000
Excavation (Scraper)	263,000	CY	$2.00	$526,000
Excavation (Dragline)	56,000	CY	$6.00	$336,000
Export to Beach (Scraper)	10,000	CY	$1.50	$15,000
Export to Disposal Site	309,000	CY	$2.50	$772,500
Disposal Fees	309,000	LS	$5.00	$1,545,000
Handling Wet Material	56,000	CY	$10.00	$560,000
Dust Control	1	LS	$225,000.00	$225,000
Cleanup	1	LS	$100,000.00	$100,000
Finish Grading	37	Ac	$8,000.00	$296,000
Access Road Maintenance	204,000	SF	$3.00	$612,000
			Subtotal:	$5,396,000
			15% Contingency:	$809,400
			**Design & Indirect Costs (21.5%):*	$1,160,140
			Total Construction Budget:	$7,365,540
			**Total Planting Budget:*	$364,325
			Total Alternative 2E:	***$7,729,865***

*See Table 12-6 for breakdown of indirect and planting costs.

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FIGURE 12-10

Alternative 2E

N W E S

1 inch equals 800 feet

0 200 400 800

12.2.3 Phase Three Construction Alternatives

Phase 3 is located adjacent to, but south and east of the model marsh and north of Phase 1 and Monument Road (Figures 12-11 to 12-15). These figures also show the configurations of proposed habitat types and the approximate elevations of those habitat types. The area of Phase 3 is approximately 75 acres. The volume of excavation required to attain the proposed elevations is approximately 901,000 cubic yards. This volume consists of about 225,000 cubic yards of sands with characteristics suitable for beach or nearshore replenishment and 676,000 cubic yards of material to be disposed of at other locations. Some of the excavated material will require wet-handling which will occur on-site, on disturbed ground. The following are descriptions of the various alternatives for the disposal of excavated material.

Alternative 3A (Figure 12-11) involves the removal of material with conventional scrapers and dragline. All of the excavated material would be loaded on to trucks, hauled on existing trails to Monument Road and then taken to Hansen El Monte Pit in Lakeside (Figure 11-2). Costs associated with this alternative are detailed in Table 12-11.

Table 12-11. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 3A

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$20,000.00	$20,000
Clearing & Grubbing	75	Ac	$1,500.00	$112,500
Erosion Control	75	Ac	$9,000.00	$675,000
Excavation (Scraper)	789,000	CY	$2.00	$1,578,000
Excavation (Dragline)	112,000	CY	$6.00	$672,000
Handling Wet Material	112,000	CY	$10.00	$1,120,000
Export to Landfill	901,000	CY	$28.00	$25,228,000
Disposal Fees	901,000	CY	$5.00	$4,505,000
Dust Control	1	LS	$400,000.00	$400,000
Cleanup	1	LS	$200,000.00	$200,000
Finish Grading	75	Ac	$8,000.00	$600,000
Access Road Maintenance	135,000	SF	$3.00	$405,000
			Subtotal:	$35,515,500
			15% Contingency:	$5,327,325
			Design & Indirect Cost (21.5%):	$7,635,832.50
			Total Construction Budget:	***$48,478,657.50***

Table 12-11. Continued

Habitat and Plantings	Area (Acres)	Quantity	Unit	Unit Cost	Cost
SUBTIDAL	13				
No planting					
MUDFLAT	18.3				
No planting					
LOW MARSH	23.7				
Rosepots, 6' o.c.		47,685	each	$13.50	$643,748
MID/HIGH MARSH	19.9				
Rosepots, 6' o.c.		27,801	each	$4.00	$111,204
TRANSITION	0				
Rosepots, 6' o.c.					
				Total Planting Budget:	$754,952
				Total Construction Budget:	$48,478,657
				Total Alternative 3A:	***$49,233,610***

Legend

	Elevation of Habitat Region	Area (acres)
Subtidal	-2'	13.0
Mudflat	0'	18.3
Low Marsh	1.5'	23.7
Mid-High Marsh	2.2'	19.9
Transition Zone	4.5' - 5'	0

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FIGURE 12-11

Alternative 3A

Alternative 3B (Figure 12-12) involves the removal of material in the same general manner as alternative 3A. However, in this alternative, 225,000 cubic yards of excavated sands suitable for beach replenishment would be hauled by trucks on existing trails to the Beach Replenishment Zone and distributed between the existing dunes and the surf zone. The remaining 676 cubic yards of material would be hauled by truck on existing trails to Monument Road and then taken to the Hansen El Monte Pit in Lakeside. Costs associated with this alternative are detailed in Table 12-12.

Table 12-12. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 3B

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$20,000.00	$20,000
Clearing & Grubbing	75	Ac	$1,500.00	$112,500
Erosion Control	75	Ac	$9,000.00	$675,000
Excavation (Scraper)	789,000	CY	$2.00	$1,578,000
Excavation (Dragline)	112,000	CY	$6.00	$672,000
Handling Wet Material	112,000	CY	$10.00	$1,120,000
Export to Beach (Scraper)	225,000	CY	$1.50	$337,500
Export to Landfill	676,000	CY	$28.00	$18,928,000
Disposal Fees	676,000	CY	$5.00	$3,380,000
Dust Control	1	LS	$400,000.00	$400,000
Cleanup	1	LS	$200,000.00	$200,000
Finish Grading	75	Ac	$8,000.00	$600,000
Access Road Maintenance	162,000	SF	$3.00	$486,000
			Subtotal:	$28,509,000
			15% Contingency:	$4,276,350
			**Design & Indirect Costs (21.5%):*	$6,129,435.00
			Total Construction Budget:	$38,914,785.00
			**Total Planting Budget:*	$754,952
			Total Phase 3B:	***$39,669,737***

*See Table 12-11 for breakdown of indirect and planting costs.

Legend

	Elevation of Habitat Region	Area (acres)
Subtidal	-2'	13.0
Mudflat	0'	18.3
Low Marsh	1.5'	23.7
Mid-High Marsh	2.2'	19.9
Transition Zone	4.5' - 5'	0

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FIGURE 12-12

Alternative 3B

N W E S
1 inch equals 800 feet
0 200 400 800

Alternative 3C (Figure 12-13) proposes to minimize trucking material offsite by excavating below the proposed finished grades. This method would produce 454,000 cubic yards of deeply dredged sands and 225,000 cubic yards of surface sands suitable for beach replenishment. The 454,000 cubic yards would be pumped to the beach and the 225,000 cubic yards would be trucked to the beach. All sands would be distributed between the existing dunes and the surf zone. The void formed by the over excavation of these sands would then be replaced with material that would normally have been hauled offsite. The remaining 222,000 cubic yards of material would be hauled along Monument Road and then taken to the Hanson El Monte Pit in Lakeside. Costs associated with this alternative are detailed in Table 12-13.

Table 12-13. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 3C

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$35,000.00	$35,000
Clearing & Grubbing	75	Ac	$1,500.00	$112,500
Erosion Control	75	Ac	$9,000.00	$675,000
Excavation (Scraper)	789,000	CY	$2.00	$1,578,000
Excavation (Hydraulic Dredge)	454,000	CY	$10.00	$4,540,000
Excavation (Dragline)	226,000	CY	$6.00	$1,356,000
Wet/Special Handling Material	680,000	CY	$10.00	$6,800,000
Export to Beach (Scraper)	225,000	CY	$1.50	$337,500
Export to Beach (Pumpline)	454,000	CY	$5.00	$2,270,000
Export to Landfill	222,000	CY	$28.00	$6,216,000
Disposal Fees	222,000	CY	$5.00	$1,110,000
Dust Control	1	LS	400,000.00	$400,000
Cleanup	1	LS	$200,000.00	$200,000
Finish Grading	75	Ac	$8,000.00	$600,000
Access Road Maintenance	162,000	SF	$3.00	$486,000
			Subtotal:	$26,716,000
			15% Contingency:	$4,007,400
			**Design & Indirect Cost (21.5%):*	$5,743,940.00
			Total Construction Budget:	$36,467,340.00
			**Total Planting Budget:*	$754,952
			Total Phase 3C:	***$37,222,292***

*See Table 12-12 for breakdown of indirect and planting costs.

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FIGURE 12-13

Alternative 3C

N W E S

1 inch equals 800 feet

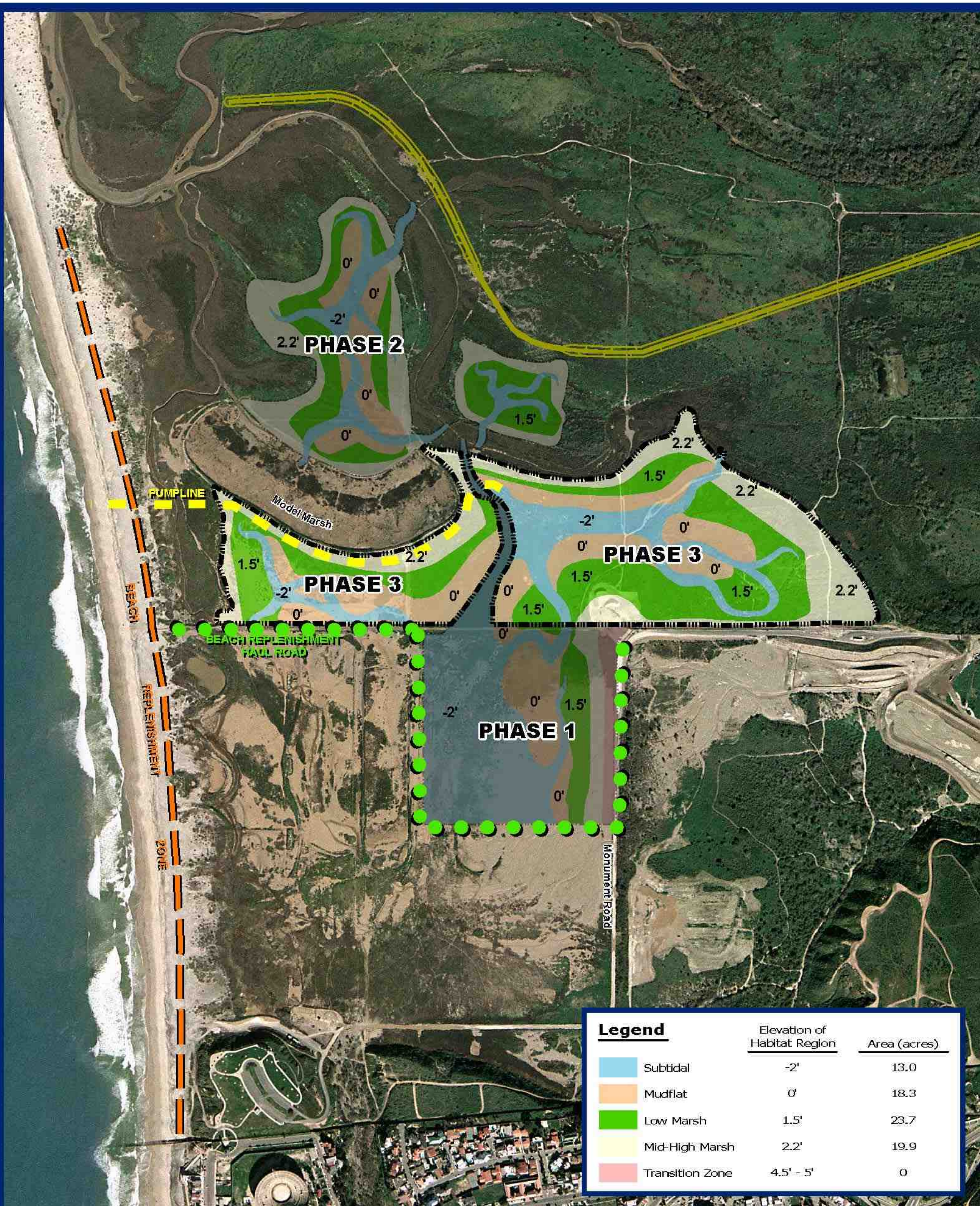
0 200 400 800

Alternative 3D (Figure 12-14) employs a different strategy to minimize hauling material by truck offsite. First, approximately 225,000 cubic yards of surface sands would be hauled to the Beach Replenishment Zone and distributed between the existing dunes and the surf zone. The remaining 676,000 cubic yards of material would be removed with a hydraulic dredge, pumped to a barge and taken to LA-5 off the coast of San Diego (Figure 11-2). Costs associated with this alternative are detailed in Table 12-14.

Table 12-14. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 3D

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$75,000.00	$75,000
Clearing & Grubbing	75	Ac	$1,500.00	$112,500
Erosion Control	75	Ac	$9,000.00	$675,000
Excavation (Scraper)	225,000	CY	$2.00	$450,000
Excavation (Hydraulic Dredge)	676,000	CY	$10.00	$6,760,000
Export to Beach (Scraper)	225,000	CY	$1.50	$337,500
Pump to Scow	676,000	CY	$10.00	$6,760,000
Tow Scow to LA-5	676,000	CY	$10.00	$6,760,000
Disposal Fees	676,000	CY	$5.00	$3,380,000
Dust Control	1	LS	$400,000.00	$400,000
Cleanup	1	LS	$200,000.00	$200,000
Finish Grading	75	Ac	$8,000.00	$600,000
Access Road Maintenance	107,000	SF	$3.00	$321,000
			Subtotal:	$26,831,000
			15% Contingency:	$4,024,650
			**Design & Indirect Costs (21.5%):*	$5,768,665
			Total Construction Budget:	$36,624,315
			**Total Planting Budget:*	$754,952
			Total Phase 3D:	***$37,379,267***

*See Table 12-11 for breakdown of indirect and planting costs.



Legend

	Elevation of Habitat Region	Area (acres)
Subtidal	-2'	13.0
Mudflat	0'	18.3
Low Marsh	1.5'	23.7
Mid-High Marsh	2.2'	19.9
Transition Zone	4.5' - 5'	0

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FIGURE 12-14

Alternative 3D

1 inch equals 800 feet
0 200 400 800

Alternative 3E (Figure 12-15) involves the removal of the excavated material and beach replenishment in the same manner as Alternative 3B. However, the remaining 676,000 cubic yards of material not suitable for beach replenishment would be taken to an alternate disposal site. Nelson Sloan pit is presumed full by this point in the excavation, so materials would be transported to Hanson Miramar Landfill, approximately 29 miles from the project site (Figure 11-2). This site is inactive and not yet reclaimed, but may be available for disposal. Costs associated with this alternative are detailed in Table 12-15.

Phase 3 would create 74.9 acres of wetland habitat with 13 acres of tidal lagoon/open water, 18.3 acres of mudflat, 23.7 acres of low salt marsh, and 19.9 acres of mid-high salt marsh. Anticipated impacts and mitigation associated with this phase are presented in Section 12.4.

Table 12-15. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 3E

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$20,000.00	$20,000
Clearing & Grubbing	75	Ac	$1,500.00	$112,500
Erosion Control	75	Ac	$9,000.00	$675,000
Excavation (Scraper)	789,000	CY	$2.00	$1,578,000
Excavation (Dragline)	112,000	CY	$6.00	$672,000
Handling Wet Material	112,000	CY	$10.00	$1,120,000
Export to Beach (Scraper)	225,000	CY	$1.50	$337,500
Export to Disposal Site	676,000	CY	$21.00	$14,196,000
Disposal Fees	676,000	LS	$5.00	$3,380,000
Dust Control	1	LS	$400,000.00	$400,000
Cleanup	1	LS	$200,000.00	$200,000
Finish Grading	75	Ac	$8,000.00	$600,000
Access Road Maintenance	160,000	SF	$3.00	$480,000
			Subtotal:	$23,771,000
			15% Contingency:	$3,565,650
			**Design & Indirect Cost (21.5%):*	$5,110,765.00
			Total Construction Budget:	$32,447,415.00
			**Total Planting Budget:*	$754,952
			Total Phase 3E:	***$33,202,367***

*See Table 12-11 for breakdown of indirect and planting costs.

Legend

	Elevation of Habitat Region	Area (acres)
Subtidal	-2'	13.0
Mudflat	0'	18.3
Low Marsh	1.5'	23.7
Mid-High Marsh	2.2'	19.9
Transition Zone	4.5' - 5'	0

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FIGURE 12-15

Alternative 3E

N W E S
1 inch equals 800 feet
0 200 400 800

12.2.4 Phase Four Construction Alternatives

Phase 4 is located south and west of Phase 3, adjacent to, and west of Phase 1 (Figures 12-16 to 12-20). These figures also show the configurations of proposed habitat types and the approximate elevations of those habitat types. The area of Phase 4 is approximately 32 acres. The volume of excavation required to attain the proposed elevations is approximately 262,000 cubic yards. This volume consists of 34,000 cubic yards of sands with characteristics suitable for beach replenishment and 228,000 cubic yards of material to be disposed of at other locations. Some of the excavated material will require wet-handling which will occur on-site, on disturbed ground. The following are descriptions of the various alternatives for the disposal of excavated material.

Alternative 4A (Figure 12-16) involves the removal of material with conventional scrapers. All of the excavated material would be hauled along a newly bladed road to Monument Road and then taken to the Hanson El Monte Pit in Lakeside (Figure 11-2). Costs associated with this alternative are detailed in Table 12-16.

Table 12-16. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 4A

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$20,000.00	$20,000
Clearing & Grubbing	32	Ac	$1,500.00	$48,000
Erosion Control	32	Ac	$9,000.00	$288,000
Excavation (Scraper)	262,000	CY	$2.00	$524,000
Export to Landfill	262,000	CY	$28.00	$7,336,000
Disposal Fees	262,000	CY	$5.00	$1,310,000
Dust Control	1	LS	$200,000.00	$200,000
Cleanup	1	LS	$100,000.00	$100,000
Finish Grading	32	Ac	$8,000.00	$256,000
Access Road Maintenance	106,000	SF	$3.00	$318,000
			Subtotal:	$10,400,000
			15% Contingency:	$1,560,000
			Design & Indirect Costs (21.5%):	$2,236,000
			Total Construction Budget:	***$14,196,000***

Table 12-16. Continued

Habitat and Plantings	Area (Acres)	Quantity	Unit	Unit Cost	Cost
SUBTIDAL	5.5				
No planting					
MUDFLAT	11.5				
No planting					
LOW MARSH	5.5				
Rosepots, 6' o.c.		11066	each	$13.50	$149,391
MID/HIGH MARSH	9.2				
Rosepots, 6' o.c.		12853	each	$4.00	$51,412
TRANSITION	0				
Rosepots, 6' o.c.					
				Total Planting Budget:	$200,803
				Total Construction Budget:	$14,196,000
				Total Phase 4A:	***$14,396,803***

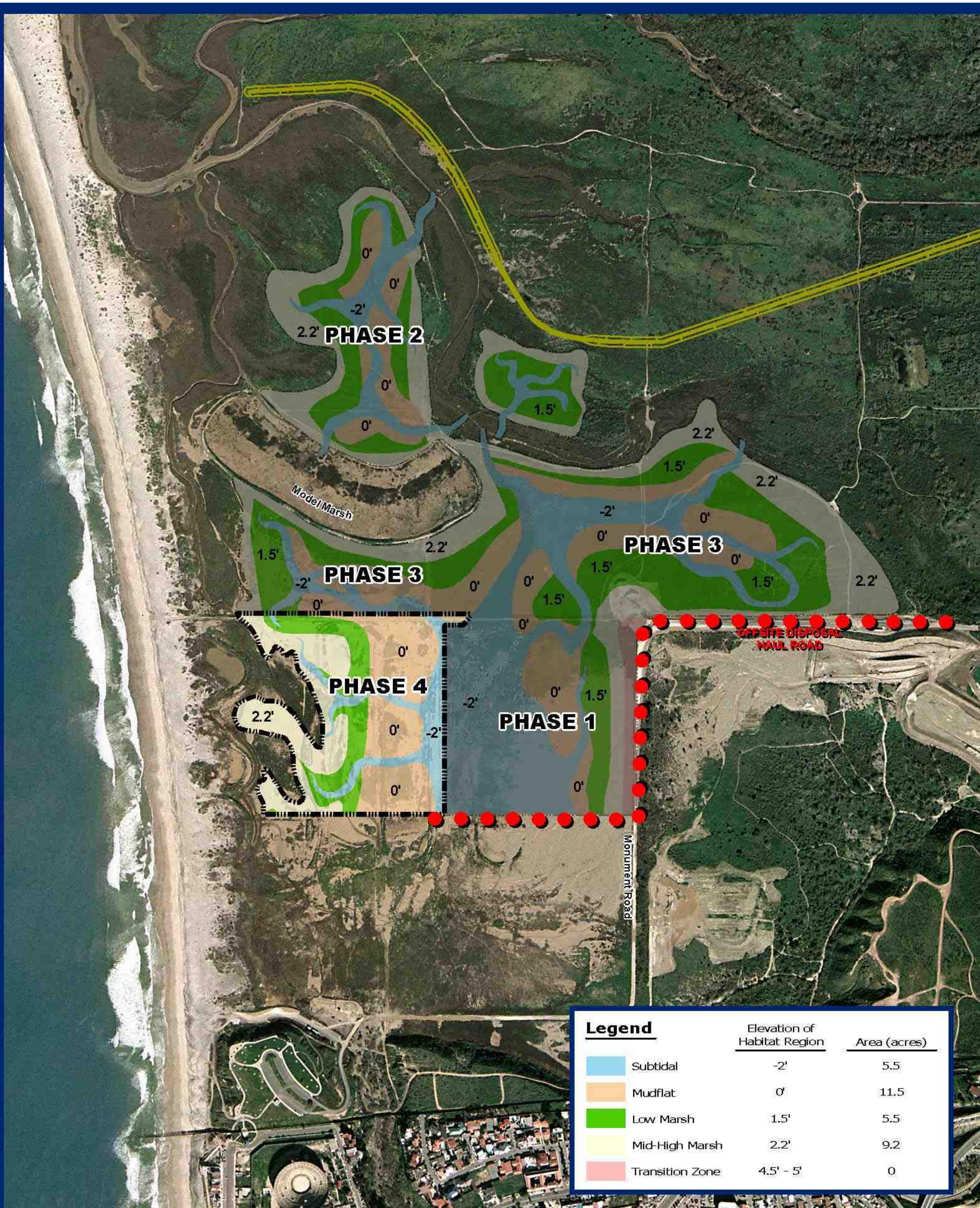

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FIGURE 12-16

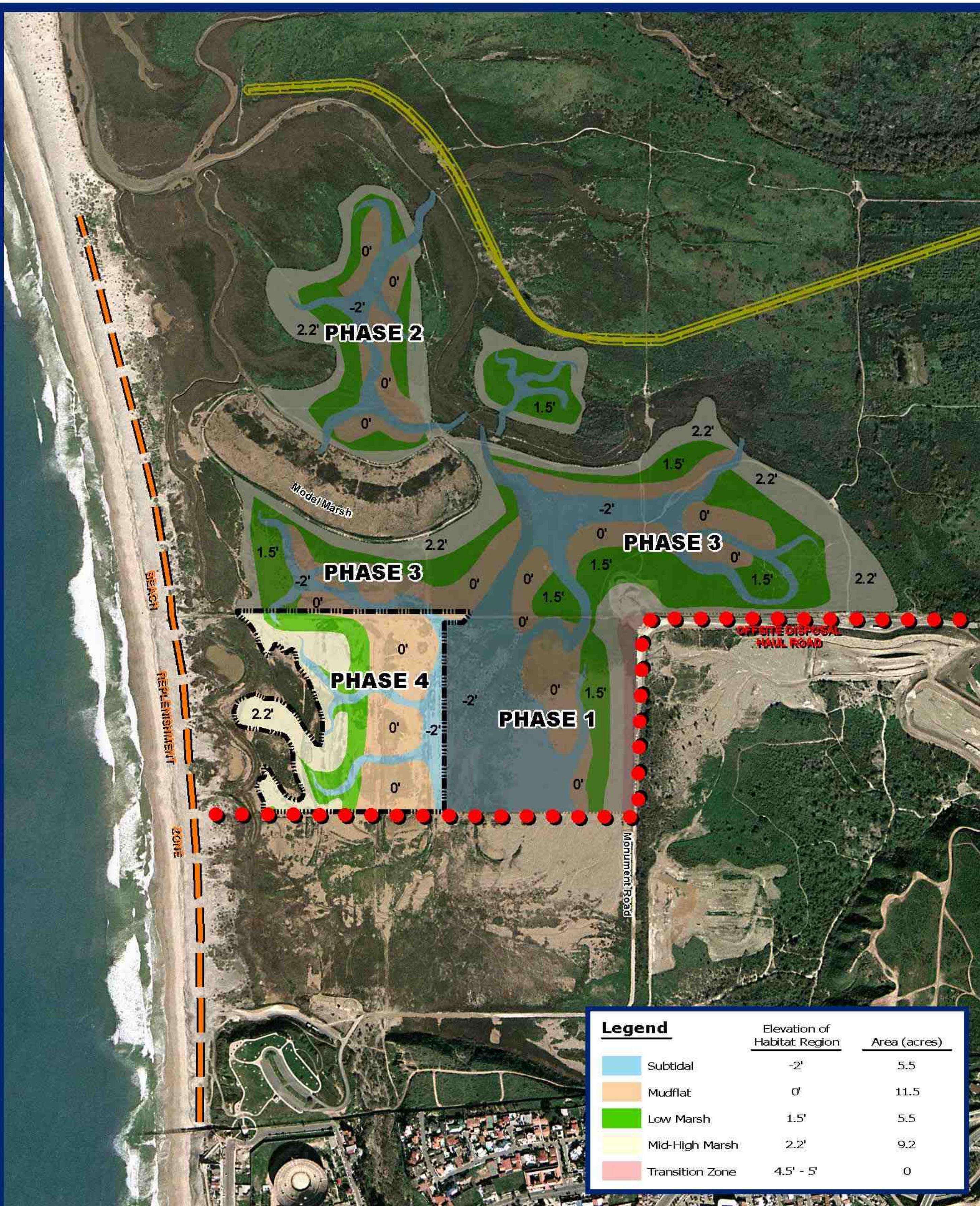
Alternative 4A

Alternative 4B (Figure 12-17) involves the removal of material in the same general manner as alternative 4A. However, in this alternative approximately 34,000 cubic yards of excavated sands suitable for beach replenishment would be hauled to Monument Road, then through the community of Imperial Beach and deposited on Imperial Beach. The remaining 228,000 cubic yards of excavated material would be hauled along Monument Road and then taken to the Hanson El Monte Pit in Lakeside. Costs associated with this alternative are detailed in Table 12-17.

Table 12-17. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 4B

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$25,000.00	$25,000
Clearing & Grubbing	32	Ac	$1,500.00	$48,000
Erosion Control	32	Ac	$9,000.00	$288,000
Excavation (Scraper)	262,000	CY	$2.00	$524,000
Export to Imperial Beach	34,000	CY	$5.00	$170,000
Export to Landfill	228,000	CY	$28.00	$6,384,000
Disposal Fees	228,000	CY	$5.00	$1,140,000
Dust Control	1	LS	$200,000.00	$200,000
Cleanup	1	LS	$100,000.00	$100,000
Finish Grading	32	Ac	$8,000.00	$256,000
Access Road Maintenance	128,000	SF	$3.00	$384,000
			Subtotal:	$9,519,000
			15% Contingency:	$1,427,850
			**Design & Indirect Costs (21.5%):*	$2,046,585
			Total Construction Budget:	$12,993,435
			**Total Planting Budget:*	$200,803
			Total Phase 4B:	***$13,194,238***

*See Table 12-16 for breakdown of indirect and planting costs.



Legend	Elevation of Habitat Region	Area (acres)
Subtidal	-2'	5.5
Mudflat	0'	11.5
Low Marsh	1.5'	5.5
Mid-High Marsh	2.2'	9.2
Transition Zone	4.5' - 5'	0

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FIGURE 12-17

Alternative 4B

N W E S

1 inch equals 800 feet

0 200 400 800

Alternative 4C (Figure 12-18) proposes to eliminate trucking material offsite by excavating below the proposed finished grades. This method would produce 228,000 cubic yards of deeply dredged sands and 34,000 cubic yards of surface sands suitable for beach replenishment. The 228,000 cubic yards would be pumped to the beach and the 34,000 cubic yards would be trucked to the beach. Sands suitable for beach replenishment will be distributed between the existing dunes and the surf zone. The void formed by the over excavation of these sands would then be replaced with material that would normally have been hauled offsite. This alternative results in no offsite material disposal. Costs associated with this alternative are detailed in Table 12-18.

Table 12-18. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 4C

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$35,000.00	$35,000
Clearing & Grubbing	32	Ac	$1,500.00	$48,000
Erosion Control	32	Ac	$9,000.00	$288,000
Excavation (Scraper)	262,000	CY	$2.00	$524,000
Excavation (Hydraulic Dredge)	504,000	CY	$10.00	$5,040,000
Wet/Special Handling Material	276,000	CY	$10.00	$2,760,000
Export to Beach (Scraper)	34,000	CY	$1.50	$51,000
Export to Beach (Pumpline)	228,000	CY	$5.00	$1,140,000
Dust Control	1	LS	$225,000.00	$225,000
Cleanup	1	LS	$100,000.00	$100,000
Finish Grading	32	Ac	$8,000.00	$256,000
Access Road Maintenance	154,000	SF	$3.00	$462,000
			Subtotal:	$10,929,000
			15% Contingency:	$1,639,350
			**Design & Indirect Costs (21.5%):*	$2,349,735
			Total Construction Budget:	$14,918,085
			**Total Planting Budget:*	$200,803
			Total Phase 4C:	***$15,118,888***

*See Table 12-16 for breakdown of indirect and planting costs.

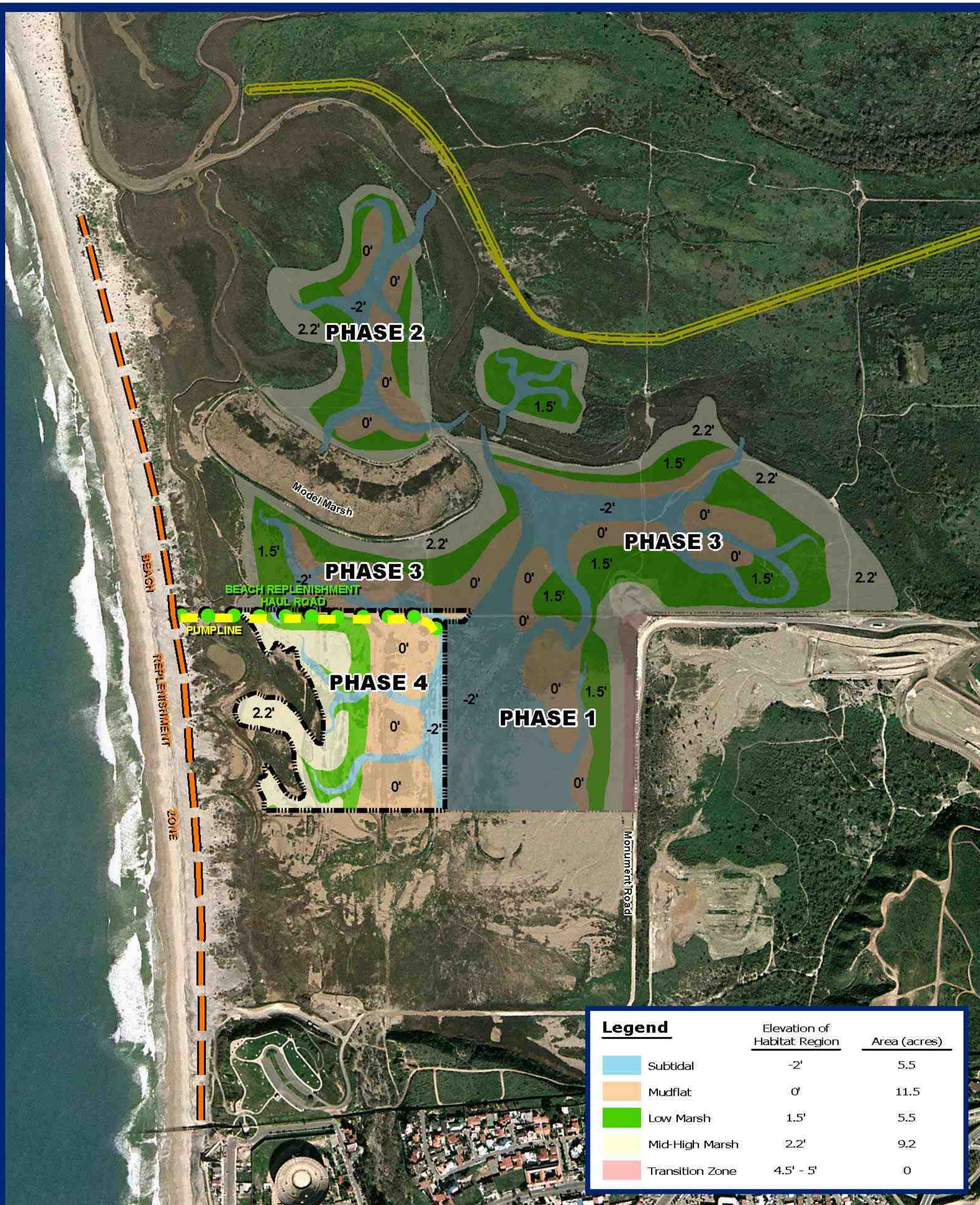

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FIGURE 12-18

Alternative 4C

N W E S

1 inch equals 800 feet

0 200 400 800

Alternative 4D (Figure 12-19) employs a different strategy to minimize hauling material by truck offsite. First, approximately 34,000 cubic yards of surface sands would be hauled on existing trails to the Beach Replenishment Zone where it would be distributed between the existing dunes and the surf zone. The remaining 228,000 cubic yards of material would be removed with a hydraulic dredge, pumped to a barge and then taken to LA-5 off the coast of San Diego (Figure 11-2). Costs associated with this alternative are detailed in Table 12-19.

Table 12-19. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 4D

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$50,000.00	$50,000
Clearing & Grubbing	32	Ac	$1,500.00	$48,000
Erosion Control	32	Ac	$9,000.00	$288,000
Excavation (Hydraulic Dredge)	228,000	CY	$10.00	$2,280,000
Excavation (Scraper)	34,000	CY	$2.00	$68,000
Export to Beach (Scraper)	34,000	CY	$1.50	$51,000
Pumpline to Scow	228,000	CY	$10.00	$2,280,000
Tow Scow to LA-5	228,000	CY	$10.00	$2,280,000
Disposal Fees	228,000	CY	$5.00	$1,140,000
Dust Control	1	LS	$225,000.00	$225,000
Cleanup	1	LS	$180,000.00	$180,000
Finish Grading	32	Ac	$8,000.00	$256,000
Access Road Maintenance	28,000	SF	$3.00	$84,000
			Subtotal:	$9,230,000
			15% Contingency:	$1,384,500
			**Design & Indirect Costs (30%):*	$1,984,450
			Total Construction Budget:	$12,598,950
			**Total Planting Budget:*	$200,803
			Total Phase 4D:	***$12,779,753***

*See Table 12-16 for breakdown of indirect and planting costs.

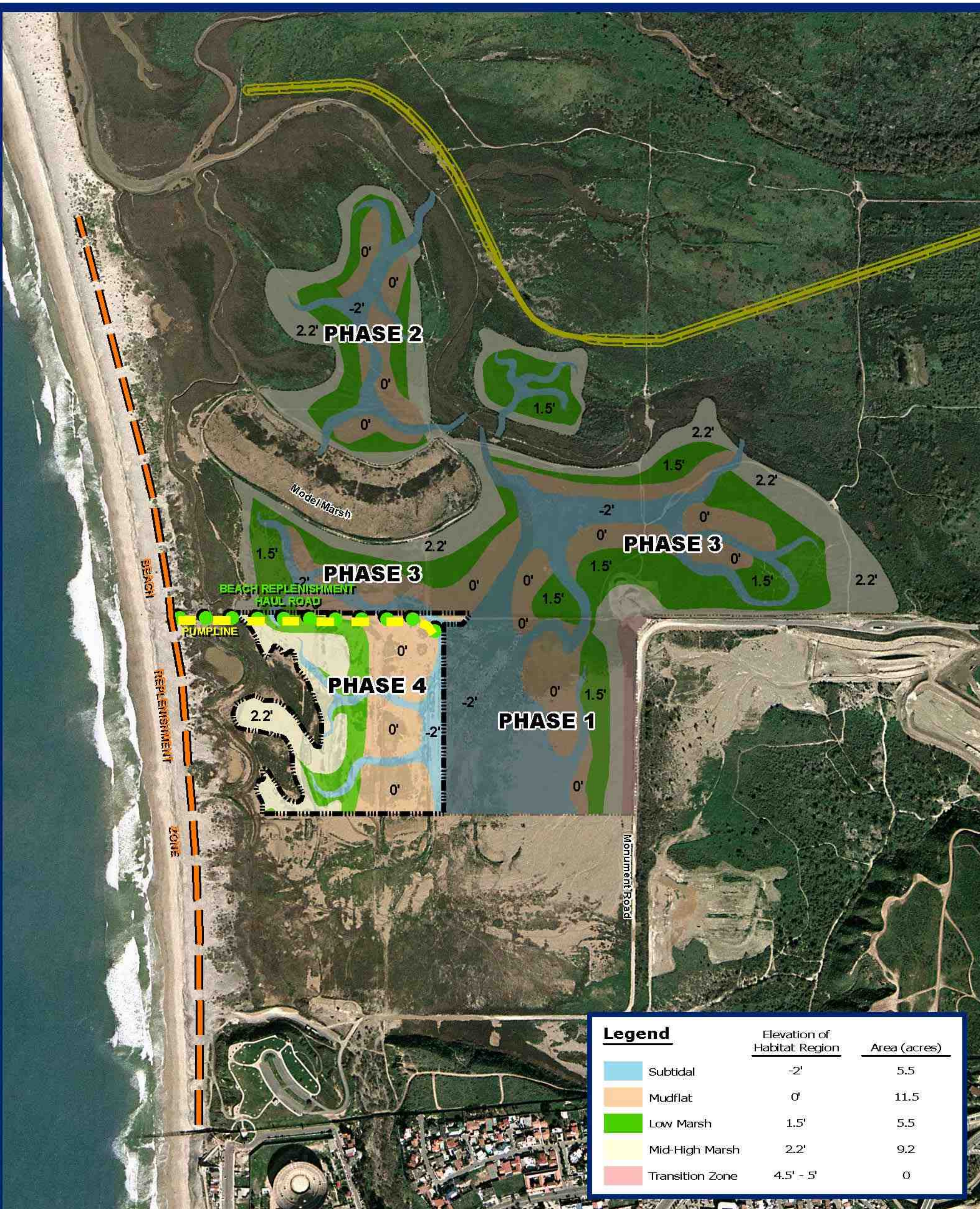

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FIGURE 12-19

Alternative 4D

N W E S

1 inch equals 800 feet

0 200 400 800

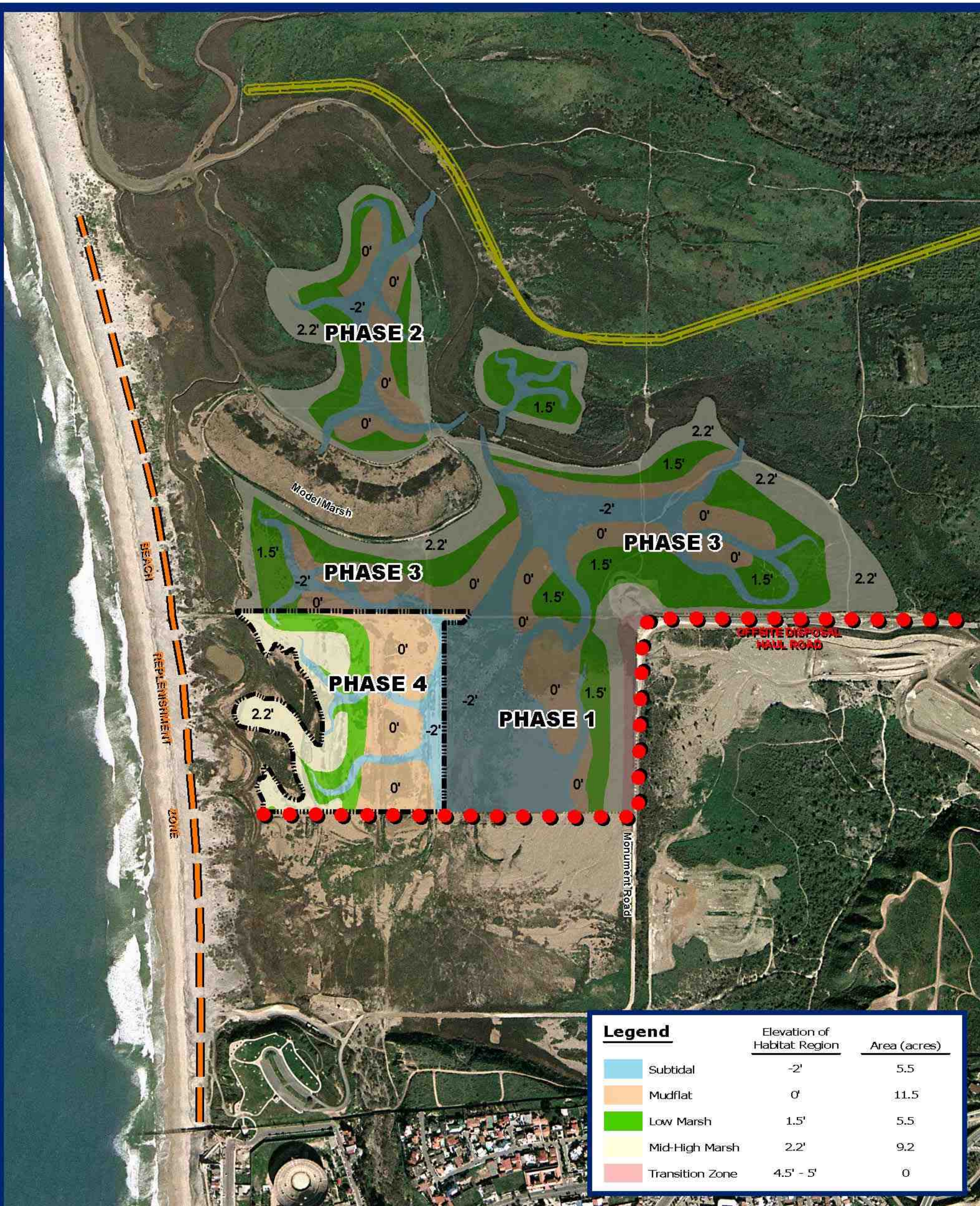
Alternative 4E (Figure 12-20) involves the removal of the excavated material and beach replenishment in the same manner as alternative 4A. However, the remaining 228,000 cubic yards of material not suitable for beach replenishment would be taken to an alternative disposal site, the Hanson Miramar Landfill, approximately 29 miles from the project site (Figure 11-2). This site is inactive, not yet reclaimed, and may be available for disposal. Costs associated with this alternative are detailed in Table 12-20.

Phase 4 would create 31.7 acres of wetland habitat with 5.5 acres of tidal lagoon/open water, 11.5 acres of mudflat, 5.5 acres of low salt marsh, and 9.2 acres of mid-high salt marsh. Potential impacts and mitigation associated with this phase are discussed in Section 12.4.

Table 12-20. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 4E

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$20,000.00	$20,000
Clearing & Grubbing	32	Ac	$1,500.00	$48,000
Erosion Control	32	Ac	$9,000.00	$288,000
Excavation (Scraper)	262,000	CY	$2.00	$524,000
Export to Beach (Scraper)	34,000	CY	$1.50	$51,000
Export to Local Disposal Site	228,000	CY	$21.00	$4,788,000
Disposal Fees	228,000	CY	$5.00	$1,140,000
Dust Control	1	LS	$225,000.00	$225,000
Cleanup	1	LS	$100,000.00	$100,000
Finish Grading	32	Ac	$8,000.00	$256,000
Access Road Maintenance	154,000	SF	$3.00	$462,000
			Subtotal:	$7,902,000
			15% Contingency:	$1,185,300
			**Design & Indirect Costs (21.5%):*	$1,698,930
			Total Construction Budget:	$10,786,230
			**Total Planting Budget:*	$200,803
			Total Phase 4E:	***$10,987,033***

*See Table 12-16 for breakdown of indirect and planting costs.



Legend	Elevation of Habitat Region	Area (acres)
Subtidal	-2'	5.5
Mudflat	0'	11.5
Low Marsh	1.5'	5.5
Mid-High Marsh	2.2'	9.2
Transition Zone	4.5' - 5'	0

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FIGURE 12-20

Alternative 4E

N W E S

1 inch equals 800 feet

0 200 400 800

12.2.5 Phase Five Construction Alternatives

Phase 5 is located south of, and contiguous with, Phases 1 and 4 (Figures 12-21 to 12-25). These figures also show the configurations of proposed habitat types and the approximate elevations of those habitat types. The area of Phase 5 is approximately 67 acres. The volume of excavation required to attain the proposed elevations is approximately 592,000 cubic yards. Unfortunately, available data needed to analyze the existing substrate material down to an elevation of -2 ft. is very limited. It appears that little or none of the material to be excavated in this phase is suitable for beach replenishment. Some of the excavated material will require wet-handling which will occur onsite, on disturbed ground. The following are descriptions of the various alternatives for the disposal of excavated material.

Alternative 5A (Figure 12-21) involves the removal of material with conventional scrapers and dragline. All of the excavated material would be loaded on to trucks and hauled along Monument Road to the Hanson El Monte Pit in Lakeside (Figure 11-2). Costs associated with this alternative are detailed in Table 12-21.

Table 12-21. Tijuana Estuary Restoration
Opinion of Probable Construction Costs – Alternative 5A

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$20,000.00	$20,000
Clearing & Grubbing	67	Ac	$1,500.00	$100,500
Erosion Control	67	Ac	$9,000.00	$603,000
Excavation (Scraper)	276,000	CY	$2.00	$552,000
Excavation (Dragline)	316,000	CY	$6.00	$1,896,000
Export to Landfill	592,000	CY	$28.00	$16,576,000
Handling of Wet Material	316,000	CY	$10.00	$3,160,000
Disposal Fees	592,000	CY	$5.00	$2,960,000
Dust Control	1	LS	$200,000.00	$200,000
Cleanup	1	LS	$100,000.00	$100,000
Finish Grading	67	Ac	$8,000.00	$536,000
Access Road Maintenance	183,000	SF	$3.00	$549,000
			Subtotal:	$27,252,500
			15% Contingency:	$4,087,875
			Design & Indirect Costs (21.5%):	$5,859,288
			Total Construction Budget:	***$37,199,663***

Table 12-21. Continued

Habitat and Plantings	Area (Acres)	Quantity	Unit	Unit Cost	Cost
SUBTIDAL	12				
No planting					
MUDFLAT	18.5				
No planting					
LOW MARSH	15.9				
Transplants, 6' o.c.		31,991	each	$13.50	$431,879
MID/HIGH MARSH	16.3				
Rosepots, 6' o.c.		22,772	each	$4.00	$91,088
TRANSITION	4.6				
Rosepots, 6' o.c.		6,426	each	$4.00	$25,704
Large rotor irrigation system		200,376	sq. ft.	$0.75	$150,282
Hydroseeding		200,376	sq. ft.	$0.15	$30,056
Weed prior to planting		200,376	sq. ft.	$0.02	$4,008
				Total Planting Budget:	$733,016.42
				Total Construction Budget:	$37,199,663
				Total Phase 5A:	*$37,932,679*

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FIGURE 12-21

Alternative 5A

Alternative 5B (Figure 12-22) involves the removal of material in the same general manner as Alternative 5A. However, because this alternative assumes that little or none of the material would be suitable sands, no beach replenishment will occur. All of the excavated material would be hauled by truck along Monument Road to the Hanson El Monte Pit in Lakeside. Costs associated with this alternative are detailed in Table 12-22.

Table 12-22. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 5B

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$25,000.00	$25,000
Clearing & Grubbing	67	Ac	$1,500.00	$100,500
Erosion Control	67	Ac	$9,000.00	$603,000
Excavation (Scraper)	276,000	CY	$2.00	$552,000
Excavation (Dragline)	316,000	CY	$6.00	$1,896,000
Export to Landfill	592,000	CY	$28.00	$16,576,000
Handling of Wet Material	316,000	CY	$10.00	$3,160,000
Disposal Fees	592,000	CY	$5.00	$2,960,000
Dust Control	1	LS	$225,000.00	$225,000
Cleanup	1	LS	$100,000.00	$100,000
Finish Grading	67	Ac	$8,000.00	$536,000
Access Road Maintenance	183,000	SF	$3.00	$549,000
			Subtotal:	$27,282,500
			15% Contingency:	$4,092,375
			**Design & Indirect Costs (21.5%):*	$5,865,738
			Total Construction Budget:	$37,240,613
			**Total Planting Budget:*	$733,016
			Total Phase 5B:	***$37,973,629***

*See Table 12-21 for breakdown of indirect and planting costs.

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FIGURE 12-22

Alternative 5B

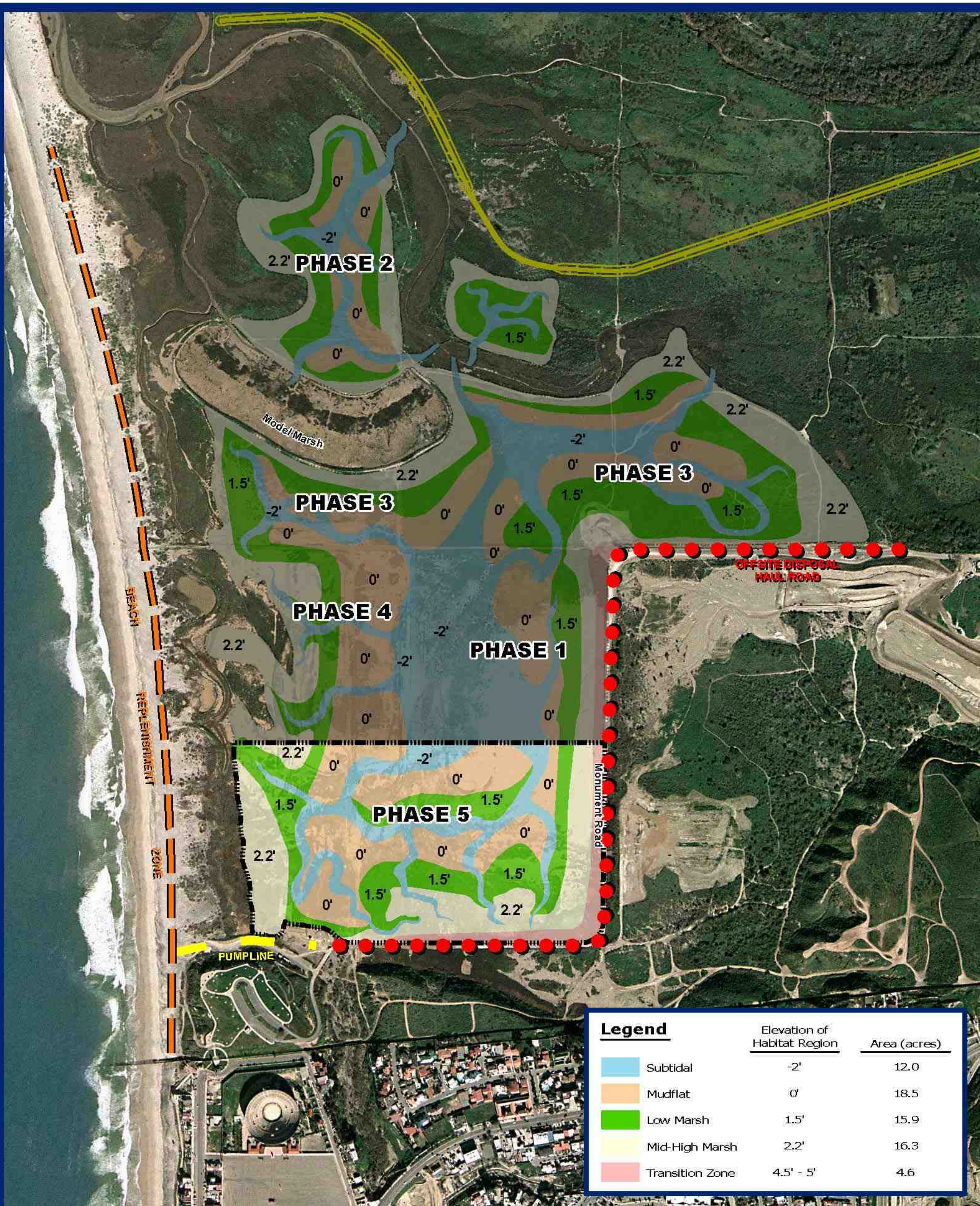
N W E S
1 inch equals 800 feet
0 200 400 800

Alternative 5C (Figure 12-23) attempts to minimize trucking material offsite by excavating below the proposed finished grades. This method would produce 288,000 cubic yards of deeply dredged sands suitable for beach replenishment. These sands would be distributed between the existing dunes and the surf zone. The remaining 304,000 cubic yards of excavated material would be hauled along Monument Road to the Hanson El Monte Pit in Lakeside. Costs associated with this alternative are detailed in Table 12-23.

Table 12-23. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 5C

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$25,000.00	$25,000
Clearing & Grubbing	67	Ac	$1,500.00	$100,500
Erosion Control	67	Ac	$9,000.00	$603,000
Excavation (Scraper)	276,000	CY	$2.00	$552,000
Excavation (Hydraulic Dredge)	904,800	CY	$10.00	$9,048,000
Export to Beach (Pumpline)	288,000	CY	$5.00	$1,440,000
Export to Landfill	304,000	CY	$28.00	$8,512,000
Wet / Special Handling Material	616,800	CY	$10.00	$6,168,000
Disposal Fees	304,000	CY	$5.00	$1,520,000
Dust Control	1	LS	$400,000.00	$400,000
Cleanup	1	LS	$200,000.00	$200,000
Finish Grading	67	Ac	$8,000.00	$536,000
Access Road Maintenance	183,000	SF	$3.00	$549,000
			Subtotal:	$29,653,500
			15% Contingency:	$4,448,025
			**Design & Indirect Costs (21.5%):*	$6,375,503
			Total Construction Budget:	$40,477,028
			**Total Planting Budget:*	$733,016
			Total Phase 5C:	***$41,210,044***

*See Table 12-21 for breakdown of indirect and planting costs.



Legend

	Elevation of Habitat Region	Area (acres)
Subtidal	-2'	12.0
Mudflat	0'	18.5
Low Marsh	1.5'	15.9
Mid-High Marsh	2.2'	16.3
Transition Zone	4.5' - 5'	4.6

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FIGURE 12-23

Alternative 5C

N W E S

1 inch equals 800 feet

0 200 400 800

Alternative 5D (Figure 12-24) employs a different strategy to minimize hauling material by truck offsite. Again, all of the 592,000 cubic yards of excavated material in this alternative are assumed to be unsuitable for beach replenishment. All material would be removed with a hydraulic dredge, pumped to a barge and taken to LA-5 off the coast of San Diego (Figure 11-2). Costs associated with this alternative are detailed in Table 12-24.

Table 12-24. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 5D

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$50,000.00	$50,000
Clearing & Grubbing	67	Ac	$1,500.00	$100,500
Erosion Control	67	Ac	$9,000.00	$603,000
Excavation (Hydraulic Dredge)	542,000	CY	$10.00	$5,420,000
Excavation (Dragline)	50,000	CY	$6.00	$300,000
Pumpline to Scow	592,000	CY	$10.00	$5,920,000
Tow to LA5	592,000	CY	$10.00	$5,920,000
Disposal Fees	592,000	CY	$5.00	$2,960,000
Dust Control	1	LS	$225,000.00	$225,000
Cleanup	1	LS	$180,000.00	$180,000
Finish Grading	67	Ac	$8,000.00	$536,000
Access Road Maintenance	4,800	SF	$3.00	$14,400
			Subtotal:	$22,228,900
			15% Contingency:	$3,334,335
			**Design & Indirect Costs (21.5%):*	$4,779,214
			Total Construction Budget:	30,342,449
			**Total Planting Budget:*	$733,016
			Total Phase 5D:	***$31,075,465***

*See Table 12-21 for breakdown of indirect and planting costs.

Legend	Elevation of Habitat Region	Area (acres)
Subtidal	-2'	12.0
Mudflat	0'	18.5
Low Marsh	1.5'	15.9
Mid-High Marsh	2.2'	16.3
Transition Zone	4.5' - 5'	4.6

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FIGURE 12-24

Alternative 5D

N W E S

1 inch equals 800 feet

0 200 400 800

Alternative 5E (Figure 12-25) involves the removal of excavated material in the same manner as Alternative 5A. However, all excavated material would be taken to an alternative disposal site, the Vulcan CC Landfill, approximately 30 miles from the project site (Figure 11-2). This site is inactive, not yet reclaimed, and may be available for disposal. Costs associated with this alternative are detailed in Table 12-25.

Phase 5 would create 67.3 acres of wetland habitat with 12 acres of tidal lagoon/open water, 18.5 acres of mudflat, 15.9 acres of low salt marsh, 16.3 acres of mid-high salt marsh and 4.6 acres of upland transitional habitat. Anticipated habitat impacts and mitigation for this phase are discussed further in Section 12.4.

Table 12-25. Tijuana Estuary Restoration
Opinion of Probable Construction Costs - Alternative 5E

Item	Quantity	Unit	Unit Price	Subtotal
Mobilization	1	LS	$20,000.00	$20,000
Clearing & Grubbing	67	Ac	$1,500.00	$100,500
Erosion Control	67	Ac	$9,000.00	$603,000
Excavation (Scraper)	276,000	CY	$2.00	$552,000
Excavation (Dragline)	316,000	CY	$6.00	$1,896,000
Export to Disposal Site	592,000	CY	$22.00	$13,024,000
Handling of Wet Material	316,000	CY	$10.00	$3,160,000
Disposal Fees	592,000	CY	$5.00	$2,960,000
Dust Control	1	LS	$200,000.00	$200,000
Cleanup	1	LS	$100,000.00	$100,000
Finish Grading	67	Ac	$8,000.00	$536,000
Access Road Maintenance	183,000	SF	$3.00	$549,000
			Subtotal:	$23,700,500
			15% Contingency:	$3,555,075
			**Design & Indirect Costs (21.5%):*	$5,095,607.50
			Total Construction Budget:	$32,351,182.50
			**Total Planting Budget:*	$733,016
			Total Phase 5E:	***$33,084,199***

*See Table 12-21 for breakdown of indirect and planting costs.

Legend

		Elevation of Habitat Region	Area (acres)
	Subtidal	-2'	12.0
	Mudflat	0'	18.5
	Low Marsh	1.5'	15.9
	Mid-High Marsh	2.2'	16.3
	Transition Zone	4.5' - 5'	4.6

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FIGURE 12-25

Alternative 5E

12.3 Summary

A summary of the costs associated with each alternative is presented in Table 12-26. A Alternatives are generally the most expensive while E Alternatives are the least expensive. Neither A nor E alternatives accomplish the goal of replenishment and dune protection. The greatest cost for all options lies in the transport of material to disposal sites. The greatest savings are derived from beneficial reuse of the excavated material.

As can be seen from this analysis, the least expensive option is to construct in phases and dispose of sediment at the Nelson Sloan Pit. It is estimated that this disposal site will be full by the time Phase 4 is ready for construction. Thus, project costs increase in the later phases.

12.4 Potential Environmental Impacts

One of the most evident impacts associated with habitat restoration on a large-scale is the conversion of one habitat type to another, e.g. conversion of degraded high marsh to fully functional tidal marsh. In the case of the Tijuana Estuary Friendship Marsh restoration, it has been demonstrated that the majority of the 250-acre project area has been heavily impacted by deliberate filling and unintentional sediment deposition. Areas that were once valuable seasonal high marsh/salt panne are succeeding to weedy upland habitats. This habitat conversion due to sediment deposition is not reversible without excavating to restore intertidal elevations. Thus, some impact to areas that once were valuable habitat must occur. However, these areas no longer function as wetlands and only remnant wetland vegetation remains associated with saline soils. Essentially no tidal flushing occurs in the project area, except in the extreme northern portion. This feasibility and design study presents a solution to this continuing loss of regionally rare habitat.

Regulators typically require that projects that impact wetland habitats be mitigated at a ratio greater than 1:1 in order to achieve a “no net loss” policy. Such mitigation often includes habitat creation at a 1:1 ratio with habitat enhancement allowed for ratios beyond 1:1. While it can be convincingly argued that restoration of a highly degraded system to a functional pristine system should not be viewed as an “impact”, regulators may not accept such arguments. In order to make permitting of the restoration plan more acceptable to regulators, the Tijuana Estuary – Friendship Marsh Restoration was designed to be as “self–mitigating” as possible. In this case, “self-mitigating” is defined as creation of new wetland habitat in areas of disturbed upland habitats. Specifically, this habitat creation is accomplished at a greater than 1:1 ratio compared to impacts to degraded wetland habitats incurred during construction. For example, if 10 acres of degraded salt marsh habitat are impacted during a phase of construction, a self-mitigating project would create more than 10 acres of functional wetland habitat from disturbed uplands as well as “enhance” degraded salt marsh habitat as it is converted to functional habitat. This concept is presented by proposed construction phase below and is summarized in Table 12-27.

Table 12-26. Disposal Options and Costs by Phase

Phase 1 - 39 acres	**Cost**	**Berm ft^3**	**Dune ft^3**	**Beach ft^3**	**Offsite ft^3**	**Ocean ft^3**	**TOTAL ft^3**	
Alternative A: No Beach + Far Offsite	$32,839,727	30,000			541,000		571,000	
Alternative B: Max Beach + Far Offsite	$29,821,713	30,000		74,000	467,000		571,000	
Alternative C: Over Ex Max Beach + Far Offsite	$24,601,953	30,000		287,000	254,000		571,000	
Alternative D: Max Beach + Ocean	$29,428,238	30,000		74,000		467,000	571,000	
Alternative E: Max Beach + Nearby Offsite	$13,559,785	30,000		74,000	467,000		571,000	
Phase 2 - 37 acres	**Cost**	**Berm ft^3**	**Dune ft^3**	**Beach ft^3**	**Offsite ft^3**	**Ocean ft^3**	**TOTAL ft^3**	
Alternative A: No Beach + Far Offsite	$18,778,855				319,000		319,000	
Alternative B: Max Beach + Far Offsite	$29,821,713		10,000		309,000		319,000	
Alternative C: Over Ex Max Beach + Far Offsite	$16,977,058		10,000	240,000	69,000		319,000	
Alternative D: Max Beach + Ocean	$17,071,243		10,000			309,000	319,000	
Alternative E: Max Beach + Nearby Offsite	$13,559,785		10,000		309,000		319,000	
Phase 3 – 75	**Cost**	**Berm ft^3**	**Dune ft^3**	**Beach ft^3**	**Offsite ft^3**	**Ocean ft^3**	**TOTAL ft^3**	
Alternative A: No Beach + Far Offsite	$49,233,610				901,000		901,000	Hanson El Monte (35 mi)
Alternative B: Max Beach + Far Offsite	$39,669,737			225,000	676,000		901,000	
Alternative C: Over Ex Max Beach + Far Offsite	$37,222,292			679,000	222,000		901,000	
Alternative D: Max Beach + Ocean	$37,379,267			225,000		676,000	901,000	
Alternative E: Max Beach + Nearby Offsite	$33,202,367			225,000	676,000		901,000	Hanson El Monte (29 mi)
Phase 4 - 32 acres	**Cost**	**Berm ft^3**	**Dune ft^3**	**Beach ft^3**	**Offsite ft^3**	**Ocean ft^3**	**TOTAL ft^3**	
Alternative A: No Beach + Far Offsite	$14,396,803				262,000		262,000	
Alternative B: Max Beach + Far Offsite	$13,194,238			34,000	228,000		262,000	Hanson El Monte (35 mi)
Alternative C: Over Ex Max Beach + Far Offsite	$15,118,888			262,000			262,000	
Alternative D: Max Beach + Ocean	$12,779,753			34,000		228,000	262,000	
Alternative E: Max Beach + Nearby Offsite	$10,987,003			34,000	228,000		262,000	Hanson El Monte (29 mi)
Phase 5 - 67 acres	**Cost**	**Berm ft^3**	**Dune ft^3**	**Beach ft^3**	**Offsite ft^3**	**Ocean ft^3**	**TOTAL ft^3**	
Alternative A: No Beach + Far Offsite	$37,932,679				592,000		592,000	Hanson El Monte (35 mi)
Alternative B: Max Beach + Far Offsite	$37,973,629				592,000		592,000	
Alternative C: Over Ex Max Beach + Far Offsite	$41,210,044			288,000	304,000		592,000	
Alternative D: Max Beach + Ocean	$31,075,465					592,000	592,000	
Alternative E: Max Beach + Nearby Offsite	$33,084,199				592,000		592,000	Vulcan CC (30 mi)

Cost Summary	**Phase 1**	**Phase 2**	**Phase 3**	**Phase4**	**Phase 5**	**Total**
Alternative A: No Beach + Far Offsite	$32,839,727	$18,778,855	$49,233,610	$14,396,803	$37,932,679	$153,181,674
Alternative B: Max Beach + Far Offsite	$29,821,713	$29,821,713	$39,669,737	$13,194,238	$37,973,629	$150,481,030
Alternative C: Over Ex Max Beach + Far Offsite	$24,601,953	$16,977,058	$37,222,292	$15,118,888	$41,210,044	$135,130,235
Alternative D: Max Beach + Ocean	$29,428,238	$17,071,243	$37,379,267	$12,779,753	$31,075,465	$127,733,966
Alternative E: Max Beach + Nearby Offsite	$13,559,785	$13,559,785	$33,202,367	$10,987,003	$33,084,199	$104,393,139

Phase 1. The construction of Phase 1 would create 39 acres of wetland habitat, but would impact only 0.06 acres of undisturbed salt marsh habitat. Total habitat impacts include: 1.02 acres of disturbed habitat; 22.73 acres of highly disturbed mule-fat scrub that was established on sediment deposited in 2005 and has since succeeded to weedy habitat; 4.93 acres of disturbed salt marsh, 0.36 acres of disturbed salt panne, 1.99 acres of disturbed uplands, and 7.67 acres of ruderal habitat.

From a regulatory perspective, impacts to all salt marsh and salt panne would require mitigation at a ratio greater than 1: 1. Thus, impacts to 4.99 acres of total disturbed and pristine salt marsh would be mitigated by creating 7.2 acres of pristine habitat from ruderal, and disturbed upland habitats. Impacts to 0.36 acre of disturbed salt panne habitat would be mitigated by creating 6.1 acres of mudflat habitat, which provides functionally superior habitat for shorebirds, insects and infauna. Impacts to highly disturbed mulefat scrub cannot be mitigated in kind in a tidal wetland restoration. This habitat, established during an episodic event, is rapidly succeeding to a ruderal, weedy habitat as there is no longer any hydraulic connection with Goat Canyon Creek. This area will be converted into open water, providing the habitat goals presented in Section 3. Thus, the creation of this phase is considered self-mitigating.

Phase 2. Construction of Phase 2 would create 37 acres of wetland habitat. Habitat impacts would include: 0.49 acres of salt marsh fleabane scrub, 1.55 acres of disturbed habitat, 12.46 acres of disturbed salt marsh, 1.34 acres of undisturbed salt marsh, 17.49 acres of non-native grassland, 0.32 acres of ruderal habitat, 0.02 acres of tidal channel, and 4.14 acres of transitional habitat.

Mitigation for impacts to 13.8 acres of combined pristine and disturbed salt marsh habitat will be accomplished through the creation of 23.5 acres of pristine salt marsh habitat from 17.49 acres of non-native grassland, 1.55 acres of disturbed areas, 0.32 acres of ruderal habitat, and 4.14 acres of transitional habitat. Mitigation is often required for non-native grassland due to its association with raptor foraging. However, from a successional perspective, this was once intertidal salt marsh that was converted to agriculture and abandoned. Thus, impacts to this habitat should be mitigated with salt marsh habitat. Mitigation requirements for impacts to transitional habitats and salt marsh fleabane scrub are unclear. These habitats are not recognized by some regulators as they are not included in Holland's descriptions of California terrestrial communities. Creation of 2.5 acres of transitional habitat in Phase 1 and 7.7 acres of open water in Phase 2 is offered as mitigation for impacts to transition and fleabane impacts. Thus, this phase is considered self-mitigating for impacts to wetland habitats.

Phase 3. Phase 3 would create 75 acres of wetland habitats. Habitat impacts would include: 0.07 acres of salt marsh fleabane scrub, 0.01 acres of brackish marsh, 4.55 acres of disturbed habitat, 13.97 acres of disturbed mule-fat scrub, 1.84 acres of mule-fat scrub, 16.79 acres of disturbed salt marsh, 0.56 acres of pristine salt marsh, 0.89 acres of disturbed southern willow scrub, 20.23 acres of disturbed upland, 8.46 acres of ruderal habitat, 2.72 acres of saltbush scrub, 4.47 acres of disturbed salt panne, and 0.45 acres of tamarisk scrub (Table 12-27).

Mitigation for impacts to 17.35 acres of combined disturbed and pristine salt marsh will be accomplished through the creation of 43.6 acres of pristine salt marsh from 20.23 acres of upland, 4.55 acres of disturbed areas, 8.46 acres of ruderal habitat, 0.45 acre of tamarisk scrub, 2.72 acre of saltbush scrub, and 7.09 acres of disturbed mule-fat scrub. Impacts to 4.47 acre of salt panne habitat will be mitigated through the creation of 18.3 acres of mudflat. In-kind mitigation for the remainder of disturbed and undisturbed mule-fat scrub and 0.89 acre of southern willow scrub cannot be accommodated in an intertidal wetland restoration. Thus, mitigation for these habitats is offered out-of-kind through the creation of open water, mudflat and salt marsh habitats.

Phase 4. The construction of Phase 4 would create 32 acres of wetland habitat. Habitat impacts would include: 1.19 acres of disturbed habitat, 0.22 acres of disturbed mule-fat scrub, 17.14 acres of disturbed salt marsh, 13.08 acres of disturbed salt panne, and 0.14 acres of disturbed upland habitat.

Mitigation for impacts to 17.14 acres of disturbed salt marsh is proposed through the creation of 14.7 acres of pristine salt marsh. Thus, as a stand alone project, Phase 4 is not self-mitigating for wetland impacts. However, by the time Phase 4 is constructed, the excess salt marsh created by Phase 3 (43.6 acres of pristine for 17.35 acres total impacts) can be applied to the overall project to make it self-mitigating. Impacts to 13.08 acres of salt panne will be mitigated through the creation of 11.5 acres mudflat and 5.5 acres of open water.

Phase 5. Phase 5 would create 67 acres of wetland habitat from disturbed habitats. Habitat impacts would include: 45.33 acres of disturbed brackish marsh, 8.06 acres of disturbed mule-fat scrub, 7.53 acres of disturbed salt marsh, 2.48 acres of disturbed salt panne, 3.66 acres of ruderal habitat and 0.06 acres of developed land. Impacts to 7.53 acres of disturbed salt marsh will be accomplished through the creation of 32.2 acres of pristine salt marsh from 3.66 acres of ruderal habitat and 28.54 acres of disturbed brackish marsh. While conversion of brackish marsh to tidal salt marsh is out-of-kind, it should be noted that this brackish marsh is not natural, but has been created by wastewater flows from Mexico. This habitat has become established at the expense of valuable salt marsh/salt panne that formerly existed at this site. With sediment input from Goat and Yogurt Canyons, this area has been raised in elevation above that which would support salt marsh. Once nuisance fresh water flows are eliminated as targeted by Reserve management, this area will likely succeed to ruderal habitat. Impacts to 2.48 acres of salt panne will be mitigated by the creation of 18.5 acres of mudflat, through conversion of the remaining 16.79 acres of disturbed brackish marsh and other disturbed habitats.

The project will impact areas that are currently occupied by breeding Belding's savannah sparrow. However, recent sedimentation events have reduced the carrying capacity for this species in the project area, a trend which is likely to continue. The project will be constructed in phases, with the first phase constructed in an area subject to extreme episodic sediment deposition in 2005. Once constructed, Phase 1 will provide approximately 10 acres of mid and high marsh as well as transition zone habitat capable of supporting breeding Belding's savannah sparrows with access to mudflat and adjacent upland habitat. Based on the density of 6.4 individuals per acre used to estimate the potential for this species (see Project Goals and Objectives, Section 3.0) this phase could support approximately 64 individuals. Subsequent phases would, likewise, affect areas that support Belding's savannah sparrow but would provide more valuable habitat for this species once constructed.

Table 12-27. Project Impacts by Proposed Phase

	Phase 1 – 39 acres			Phase 2 - 37.3 acres			Phase 3 – 74.9 acres			Phase 4 – 31.7 acres			Phase 5 – 67.3 acres		
	Impact			Impact			Impact			Impact			Impact		
	Pristine	**Disturbed**	**Creation**	**Pristine**	**Disturbed**	**Creation**	**Pristine**	**Disturbed**	**Creation**	**Pristine**	**Disturbed**	**Creation**	**Pristine**	**Disturbed**	**Creation**
Tidal Open Water			22.9	0.02		7.7			13			5.5			12
Channel															
Mudflat			6.1			6.1			18.3			11.5			18.5
Low Salt			4.1			10.8			23.7			5.5			15.9
Mid-High Salt			3.1			12.7			19.9			9.2			16.3
High Salt															
Salt Marsh Subtotal	***0.06***	***4.93***	***7.2***	***1.34***	***12.46***	***23.5***	***0.56***	***16.79***	***43.6***		***17.14***	***14.7***		***7.53***	***32.2***
Brackish Marsh							0.01							45.33	
Salt Marsh Fleabane Scrub				0.49			0.07								
Salt Panne		0.36						4.47			13.08			2.48	
Mule-fat Scrub		22.73					1.84	13.97			0.22			8.06	
Southern Willow Scrub								0.89							
Saltbush Scrub								2.72							
Tamarisk Scrub								0.45							
Ruderal		7.67			0.32			8.46						3.66	
Transition			2.5	4.14											4.6
Non-native Grassland				17.49											
Upland		1.99						20.23			0.14				
Developed														0.06	
Disturbed		1.02			1.55			4.55			1.19				
Total	**0.06**	**38.7**	**38.7**	**23.03**	**14.33**	**37.3**	**2.48**	**72.53**	**74.9**		**31.77**	**31.7**		**67.12**	**67.3**
Total Impact	**38.76**			**37.36**			**75.01**			**31.77**			**67.12**		

13.0 RESTORATION PLANTING PROGRAM

The Preferred Project Alternative will result in the restoration of 250.27 acres of wetland habitats. Currently, wetland habitats within the project footprint can be best described as disturbed to highly disturbed. Once the restoration process is complete, the quality of vegetation, proportion of total vegetation cover and proportion of open space in the restored marsh should be similar to those found in native habitats occurring in the northern arm of the marsh. The restoration project will create five types of coastal salt marsh habitat (Table 13-1) and return essential tidal flushing to the project area. Restoration goals for the establishment of native vegetation within the project area are outlined below.

Table 13-1. Summary of Net Wetland Habitat Creation - Project Components

Habitat Type	Restored Area (Acres)
Tidal Wetland (below +4.5 feet, NGVD)	
Subtidal	61.15
Mud-flat	60.66
Low Marsh	60.03
Mid-High Marsh	61.32
Nontidal (above+4.5 feet)	
Transition Zone	7.11

13.1 Restored Habitats

Low marsh in southern California salt marshes is dominated by cordgrass (*Spartina foliosa*), which forms a thick canopy approximately three feet in height. This is the preferred nesting habitat of the light-footed clapper rail (*Rallus longirostris levipes*), a federal-listed and state-listed endangered bird. Therefore, creation of this habitat is critical to the recovery of this species.

Although mid-high marsh is typically dominated by pickleweed (*Salicornia virginica*), several other plant species are associated with this community. In past restoration projects at Tijuana Estuary, the natural recruitment of pickleweed has been highly successful and this species may even become excessively dominant if planted. Therefore, this species will not be planted, but allowed to colonize the restoration site naturally.

Transition zone habitat is defined as the area that transitions from wetland to upland. In this case, the transition zone is that area between the seasonal high marsh and the non-native grassland or ruderal habitat that typify the upland habitat of the project area. At Tijuana Estuary, the transition zone occurs between approximately 9 and 11 feet above NGVD (Zedler et al. 1992). Transitional habitat supports a variety of wetland plant species as well as some upland species.

Transition zone vegetation supports important insect pollinators as well as numerous snakes, lizards, mammals and birds. Common snake species observed in this zone at Tijuana Estuary include California king snake (*Lampropeltis getula californiae*) and gopher snake (*Pituophis catenifer annectens*). Regionally rare bird species that utilize these habitats include short-eared owl (*Asio flammeus*), northern harrier and white-tailed kite (*Elanus caeruleus*).

13.2 Habitat Planting Plan

In order to achieve project goals, tidal, non-tidal and upland habitats must be established within the restored areas. These areas have been divided into habitat zones, including sub-tidal, mudflat, low marsh, mid-high marsh and transition zones. Sub-tidal and mudflat areas do not support vegetation and, therefore, will not be planted. Complete planting budgets are included with construction budgets in Section 12.0 for each restoration alternative. Detailed descriptions of planting plans for each habitat zone are provided below and are illustrated in Figure 13-1.

13.2.1 Low Marsh

The restored low marsh areas will be planted exclusively with California cordgrass (*Spartina foliosa*). All cordgrass will be obtained from plants occurring within the Tijuana Estuary. Cordgrass root divisions, referred to as "plugs", are obtained by dividing existing stands of cordgrass into small divisions composed of two to five growing stems and attached rhizomes/roots. Each cordgrass plug is approximately six inches in diameter including attached native soil which buffers the plant from transplant shock. Plugs are harvested by hand, transported to the transplant site, and replanted within a 24-hour period. Cordgrass plantings will receive tidal inundation and will not require irrigation. All cordgrass plantings will be spaced at 6 feet on center (o.c.) (Table 13-2).

13.2.2 Mid-High Marsh

The mid-high marsh zone will be planted with equal proportions of saltwort (*Batis maritima*), saltgrass (*Distichlis spicata*), alkali heath (*Frankenia salina*), jaumea (*Jaumea carnosa*), sea lavender (*Limonium californicum*), shoregrass, (*Monathochloe littoralis*), glasswort (*Salicornia subterminalis*), sea blite (*Suaeda esteroa*), and arrow grass (*Triglochin concinna*). All species are propagated from cuttings harvested from the existing salt marsh of Tijuana Estuary. Individual plants are grown to suitable size in 2.25 inch wide, 3-inch deep, "rosepot" liners (Table 13-2). All rosepots will be planted at 6 feet o.c. spacing and irrigated as described in Section 13.3.

13.2.3 Transition Zone

The upland transition zone will be planted with equal proportions of alkali weed (*Cressa truxillensis*), saltgrass, boxthorn (*Lycium californicum*), shoregrass, glasswort and sea blite (Table 13-2). All species will be propagated from cuttings or seed harvested the estuary. Individual plants will be grown to suitable size in rosepot liners (Table 13-1). Supplemental seeding of the same species will also occur in the transition zone. All rosepots will be planted at 6 feet o.c. spacing and irrigated as described in Section 13.3.

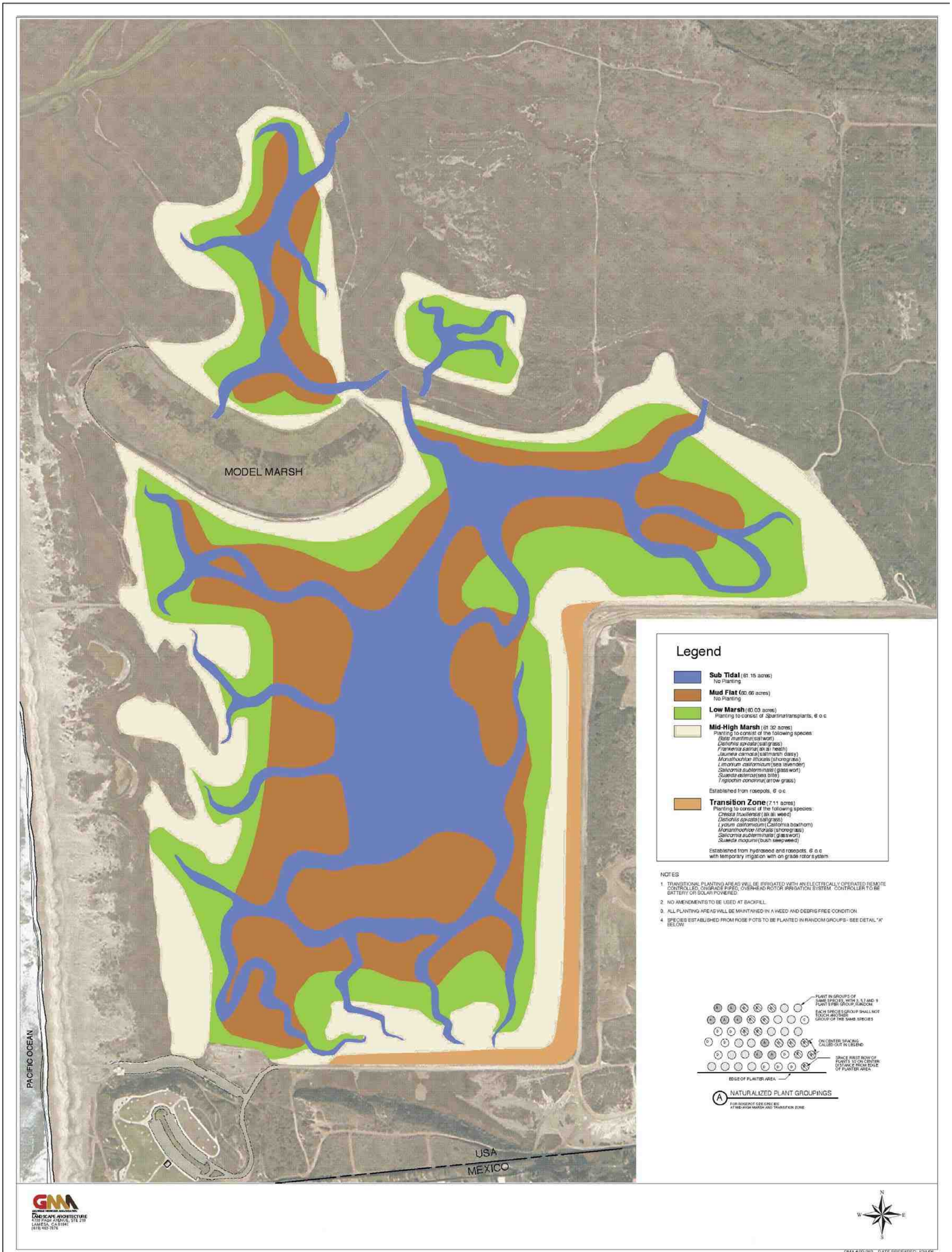

FIGURE 13-1 **Preliminary Habitat Planting Plan**

Table 13-2. Plant Species to be Planted Within Each Habitat Zone, Propagule Form and Method of Establishment

Habitat Type	Elevation (ft, NGVD)	Acres/ Spacing	Scientific Name	Propagule Form and Method of Establishment
Low Marsh	1.5	60.3 acres/ 6' o.c.	*Spartina foliosa*	Rooted plugs Allow to naturalize
Mid High Marsh	2.2	61.32 acres/ 6'o.c.	*Batis maritima* *Distichlis spicata* *Frankenia salina* *Jaumea carnosa* *Limonium californicum* *Monathochloe littoralis* *Salicornia subterminalis* *Suaeda esteroa* *Triglochin concinna*	Rosepots Allow to naturalize
Transition Zone	4.5 to 5	7.1 acres/ 6' o.c.	*Cressa truxillensis* *Distichlis spicata* *Lycium californicum* *Monathochloe littoralis* *Salicornia subterminalis* *Suaeda esteroa*	Rosepots and seed Allow to naturalize

13.2.4 Planting Details

In an effort to ensure adequate establishment and balanced representation of each species within the mid-high marsh and transition zones, plantings will occur in groupings. Specifically, each species will be planted in groupings of three-to-nine individuals in a reasonably random grouping pattern within the planting zone. To ensure that large monoculture plant groupings do not result in this design, each species grouping cannot occur immediately adjacent to another grouping of the same species. This method should result in a random patchwork of each species across each habitat zone.

When initiating the planting pattern, care will be taken to ensure that the first row of plants is spaced 2.5 to 3 feet from the edge of the planting zone. This measure will ensure adequate spacing is maintained between adjacent planting zones. Initially these plantings will appear sparse, but plantings are expected to establish quickly and naturalize within three to five years to form dense cover typical of undisturbed salt marsh habitats.

The majority of plant material will be provided in rose pot liners that have been successfully used before in salt marsh restoration projects at Tijuana Estuary. All plants will be planted in holes of sufficient depth to accommodate the root mass and any attached soil. Holes will then be back-filled with native soil. Care will be taken to ensure that the entire root mass is buried and not exposed to air and sunlight.

Many of the wetland plants selected for restoration planting already occur within the restoration site. These plants can be a valuable source of propagules for use in the replanting plan. Where possible, these existing valuable plants may be salvaged and stored on-site for subsequent division and re-planting in the restoration.

13.3 Irrigation

The goal of the low marsh restoration is to match the grades of the adjacent salt marsh that is inundated by diurnal tides. Therefore, much of the site should not require irrigation. However, the higher marsh and transition zones will be less influenced by tides. In portions of the restoration receiving infrequent or no tidal inundation, supplemental watering will be required for the first full year after planting.

Hand watering via a portable water truck is not feasible for this project because access routes to much of the restored marsh will not be retained. As a result, a temporary, above ground irrigation system with fixed-head rotary sprinklers will be required. This system should be connected to the potable water system accessible along Monument Road. Irrigation of new plantings will be most critical within the 120-day plant establishment period and will become less critical as plants develop greater root mass over time.

13.4 Maintenance

Due to the high interstitial soil salinities of areas receiving tidal inundation, the low and mid-high marsh planting zones should not require any weeding maintenance. Weedy non-native species are unlikely to invade these areas. However, the transition zone, especially when irrigated, is likely to require periodic hand weeding. In addition, plant losses may occur among new plantings in the project area. These plants will be replaced as losses occur.

13.5 Success Criteria

The goal of the restoration is to achieve vegetation densities and structure within the restoration area typical of natural salt marsh habitats at Tijuana Estuary. Success of the restoration will be determined by evaluating survivorship of new plantings, plant establishment rates and general health and vigor of restored vegetation. Regular monitoring will occur to ensure accomplishment of success criteria. The monitoring program is detailed in Section 14.0.

The project goal is to achieve at least 80% survivorship of all plantings in the first year and 100% survivorship thereafter. Any mortality exceeding 20% will require remedial re-planting. Percent cover is expected to increase gradually each year, reaching 90% or higher cover within three to five years.

14.0 PROJECT EVALUATION METHODS AND SUCCESS CRITERIA

In Section 3.0, seven major project goals were outlined and developed for this project. These goals included:

- Goal 1. Increase tidal prism.
- Goal 2. Restore areas of former salt marsh, tidal channel, and mudflat affected by sedimentation to the maximum extent possible.
- Goal 3. Restore barrier beach and dunes.
- Goal 4. Increase habitat for endangered species.
- Goal 5. Increase area of undisturbed transition zone.
- Goal 6. Build in topographic relief to prevent sudden loss of restored habitat from flood events.
- Goal 7. Incorporate research and adaptive management.

In order to determine whether these goals have been achieved, each component of the restoration must be compared to success criteria established a-priori. This evaluation is accomplished thorough repetitive monitoring of biological or physical attributes of the restored system. The terms “evaluation” and “assessment” may be used interchangeably. As defined by Zedler et al. (2001), “Assessment is the quantitative evaluation of selected ecosystem attributes, and monitoring is the systematic repetition of the assessment process…” Thus, the restoration will be evaluated in terms of its progress towards restoration targets (success criteria). An effective monitoring plan must be able to evolve, i.e., be streamlined or expanded based on past data, using an iterative process known as “adaptive management” (Zedler et al. 2001). This section presents a proposed monitoring plan to assess the success of the overall restoration plan, once it has been implemented. Much of the information summarized here has been presented in a *Handbook for Restoring Tidal Wetlands* (Zedler et al. 2001). It is anticipated that this monitoring plan will be refined in subsequent project documents.

The ecosystem attributes to be monitored can be divided into physical and biological components. Physical attributes include hydrology, topography, and soils. Biological attributes include vegetation, aquatic biota, and birds. A conceptual monitoring plan is presented in detail below.

14.1 Physical Processes

14.1.1 Hydrology and Topography

Hydrology and topography are interrelated. The tidal regime is influenced by erosion and sedimentation while hydrology drives the establishment of wetland habitats. Changes in hydrology affect the viability of the system as evidenced by the role that erosion and sedimentation have played in shaping the condition of the project area today.

14.1.2 Tidal Regime

Tidal regime will be measured remotely using data loggers that measure depth and duration of the tidal cycle. Data loggers will be deployed in series across a gradient, such as from the mouth of the estuary to the restored site, to measure tidal lags and attenuation of tidal amplitude. In addition, data loggers will be deployed in reference sites to compare the functioning of the constructed marsh with the natural system.

For the purposes of this feasibility study, it is recommended that data loggers be placed at the tidal inlet, at the confluence of the main tidal basin and Old River Slough, and at various locations along newly constructed channels. The precise placement of data loggers will be determined during preparation of engineering and environmental documents for the first phase of construction.

14.2 Changes in the Marsh Surface

14.2.1 Channels and Tidal Creeks

Channels and tidal creeks are important morphological features in the constructed marsh. They provide habitat for fishes and invertebrates; provide an interface between vascular plants and algae, and fish and invertebrate assemblages; and convey nutrients and dissolved oxygen, as well as sediment. Development of tidal creeks within the marsh plain will be assessed through analysis of high-resolution aerial photographs. Channel and tidal creek development will be monitored using aerial photographs and ground-based surveys, including surveys of cross sections of selected creeks and channels.

Certain channels and tidal creeks will be engineered, while others will be allowed to develop naturally. Engineered channels and tidal creeks should be dendritic, but not too complicated. Complicated tidal creek systems constructed in the Model Marsh have partially filled with sediment, while natural channels appeared to be less affected by sediment filling. This adaptive management will be applied to future restoration units.

14.2.2 Elevation

Evidence from the Model Marsh project suggests that the elevations of the newly created marsh plain and tidal channels are likely to change following construction. Sediment loosened during construction can migrate into channels and may result in the loss of those channels. Sediment may also be deposited on the marsh plain, effectively raising it beyond its target elevation. A potential reduction in the capacity of creeks and channels to convey flows can reduce the available habitat for fishes and invertebrates. It can also reduce tidal prism, attenuate tidal exchange, and reduce nutrient and oxygen influx. Thus, elevation monitoring is a vital component of the long-term program.

Elevation on the marsh plain and tidal channels can be monitored using standard total station surveying equipment or marker horizons. Surveying is useful in cases where there has been a relatively large change in elevation (greater than 2 cm). Marker horizons are more useful for smaller scale changes. Because total station surveying requires that at least one person be present in the marsh to walk transects through the area, this method can be potentially damaging to the marsh vegetation and may have seasonal restrictions. Marker horizons are much less intrusive, are relatively inexpensive and have a high degree of accuracy.

Marker horizons involve the use of a layer of feldspar laid down on the marsh surface at predetermined locations. The marker is sampled at subsequent dates using a small coring device. The depth of recently deposited sediment found on top of the feldspar layer is measured, indicating the vertical accretion of sediment over time.

The following program is recommended for monitoring changes in marsh plain and tidal elevation of the constructed marsh. The final grade of the constructed marsh plain and creeks will be surveyed using total station surveying equipment based on reliable existing USGS benchmarks. These data will serve as the "as-built" conditions of the project. Tidal creek elevations will be monitored using total station surveying equipment as the initial changes are likely to be greater than 1-2 cm. Marsh plain elevations will be monitored using feldspar markers. Both techniques will be deployed at the project reference sites to determine site-specific versus system-wide events.

14.2.3 Water Quality

The physical and chemical constituents of tidal water are important indicators of water quality. Poor water quality may indicate impaired functioning of constructed tidal channels and creeks. Temperature is important in its relationship to dissolved oxygen and in properly evaluating water column stratification and the effects of tidal residence time. Low dissolved oxygen levels can be stressful, even fatal, for estuarine organisms. Although many estuarine organisms are euryhaline, fluctuations in salinity can also result in changes in the population structure of fishes and invertebrates (Nordby and Zedler 1991). Remote data loggers can measure the target water quality parameters, including temperature, dissolved oxygen, salinity, pH and turbidity. For the purposes of this feasibility study, it is recommended that water quality be monitored using the remote data loggers deployed to measure tidal regime. These results can be compared to long-term water quality data collected in the northern arm of the estuary.

14.2.4 Soil Salinity

Soil salinity is very important in the early stages of wetland restoration. Newly exposed soils often concentrate salts resulting in soil salinities that are 3-4 times as saline as salt water (34 ppt). These hypersaline soils often cause a high mortality of salt marsh vascular plants installed as part of an active restoration project. Soil salinity is highly variable over time and space, changing in response to tidal inundation, rainfall and evaporation. In this study, soil salinity will be measured at the beginning and the end of the growing season, along transects established for monitoring vegetation (see below). A salinity measurement will be taken at the beginning and end point of each transect. Salinity will be measured by expressing a drop of soil water through a syringe lined with filter paper onto a hand-held optical salinity refractometer. This method has been used successfully in the past to measure soil salinities at Tijuana Estuary.

14.3 Vegetation

According to Zedler et al. (2001), monitoring salt marsh vegetation is perhaps the most effective means of assessing the development of restored marsh systems. Periodic assessment of the plant community provides the basis for determining how the restored marsh functions relative to reference sites. In many cases, vegetation monitoring is used to assess the success of the project, defined by predetermined success criteria, such as canopy development. Vegetation sampling should be conducted simultaneously at reference sites in order to interpret changes at the restored site.

The first step in monitoring the vegetation of the restored marsh is to map the habitats created. In the project area, the following vegetated habitats will be created: low marsh (cordgrass-dominated); mid- and high marsh (dominated by a mosaic of primarily succulent species); and transition zone. Once mapped, representative subunits can be sampled in greater detail using permanent transects. The methods described here have been used to monitor vegetation at the Model Marsh and Oneonta Tidal Connector Channel, the first phases of restoration conducted under the Tijuana Estuary Tidal Restoration Project.

Vegetation is sampled twice annually; once at the beginning of the growing season (March) and at the end of the growing season (September). Although some salt marsh vascular plant species continue to grow throughout the year, particularly below ground (e.g., *Spartina foliosa*), most dominant species enter a period of dormancy during the winter. Vegetation monitoring will be measured along permanently established transects. Both qualitative and quantitative data will be collected as part of these monitoring surveys. Collection of qualitative data involves documentation of the overall health and vigor of the plants as well as site conditions and photo documentation of site conditions from permanent photographic stations.

In order to document the changes in canopy cover over time, permanent transects will be established on the restoration site within the following habitats:

- cordgrass-dominant low marsh habitat;
- succulent-dominant mid- and high-marsh; and,
- transitional habitat.

Plant development and percent cover will be assessed using the point-intercept method recommended by the California Native Plant Society (CNPS), which involves dropping a vertical line at 0.5-meter intervals along each transect. Each species intercepted by the vertical line is recorded. To calculate percent cover, that is, the proportion of area covered by the plant canopy relative to bare ground, the number of points that intercept live plant material are summed and divided by the total number of possible intercepts. Each point at 0.5-meter intervals is counted as one intercept. Multiple hits of plant material at a single point from overlap of two or more species are counted as one intercept.

To calculate the percent of vegetative cover contributed by each species (relative cover), the number of hits by each species is summed, including those hits that overlap with hits by other species. This sum is divided by the total number of points that intercept live plant material. For this denominator, each point along the transect is counted as one hit regardless of the number of species that intercept the transect at that point. For example, along a 50-meter transect, bare ground may account for 15 hits and vegetation for 85 hits. Of these 85 hits, pickleweed may account for 40 hits and cordgrass for 45 hits. Therefore, pickleweed accounts for 47% (40/85) of vegetative cover and cordgrass accounts for 53% (45/85). On a transect with overlap between species, pickleweed might account for 50 hits and cordgrass for 50 hits even though total vegetation covers only 85 hits on the transect. In this case, each species accounts for 59% (50/85) and species contribution to vegetative cover sums to greater than 100% (118%).

To assess plant survivorship, surviving planted individuals will be counted within a 5-meter (16-foot) belt transect (2.5 meters, or 8 feet, on either side of the transect line). To calculate survivorship for each area, surviving plants will be counted by species, divided by the number of individuals expected for that area based on the planting plan and multiplied by 100. Species composition, or diversity of species present, will also be assessed within this 5-meter belt area. All species observed in the area, including native, non-native, planted and non-planted species, will be recorded**.**

Information on species presence or absence and percent cover will be collected using the cover class method, which involves placing a 0.25-m^2 quadrat over the vegetation at 5 or 10 meter intervals. Within each quadrat, the percent of total coverage contributed by all species present as well as the percent cover contributed by each species is determined and recorded as one of six cover classes: 1) 0 to 1% cover, 2) 1 to 5% cover, 3) 6 to 25% cover, 4) 26 to 75% cover and 5) 76 to 100% cover. This method will be employed for future comparisons with reference sites in the north arm of Tijuana Estuary, where cover class data have been collected for decades. As the canopy of the restored site develops and plant canopies coalesce, direct counts of survivorship become impractical and infeasible. When this occurs, comparison of species occurrence and percent cover using the cover class method becomes more practical and useful.

Soil salinities will be recorded during the monitoring survey from soil samples collected at depths of 3 to 5 centimeters (1 to 2 inches) below the marsh surface at each end of each transect. This soil is placed into a syringe lined with two disks cut from Size 5, 110-millimeter Whatman filter paper. The syringe is then compressed in order to filter existing interstitial soil water through the paper. The interstitial water is placed on the surface of a soil refractometer calibrated with de-ionized water. A salinity reading is then taken through the refractometer eyepiece.

14.4 Aquatic Organisms

14.4.1 Invertebrates

Monitoring of benthic invertebrate assemblages can be used to evaluate the health and functioning of restored wetlands due to their importance in estuarine food webs. Measurements of density and diversity are commonly compared to reference sites. Benthic invertebrates can affect, and be affected by, benthic processes such as erosion, sedimentation and nutrient cycling. While it is obvious that a sudden deposition of sediment may have a negative effect on a benthic invertebrate population, it is less obvious that these organisms may contribute to the suspension and redistribution of sediment. Thus, simultaneous sampling of restored sites and reference sites must be conducted.

When choosing sampling stations and reference sites, the factors that affect invertebrate species composition and density must be considered. Physical factors such as sediment type, water depth, salinity, temperature, flow rate, and presence or absence of submerged aquatic vegetation all influence invertebrate populations. Where possible, both restored marsh monitoring sites and reference sites should be physically similar.

Like salt marsh vascular plants, invertebrate assemblages vary in composition and abundance over spatial and temporal scales, and monitoring should be designed to accommodate these shifts. For example, in southern California lagoons and estuaries, many invertebrates are reduced in abundance during winters with unusually heavy rainfall that affects water salinity. Conversely, such assemblages often peak in terms of abundance during summer months, when factors such as salinity and temperature are more constant. For the purposes of this study, it is recommended that benthic invertebrate sampling be conducted in both summer and winter to document potential extremes in composition and abundance.

The methods proposed here for assessing benthic invertebrates follow those used by the Pacific Estuarine Research Laboratory (PERL) in other parts of Tijuana Estuary and other southern California lagoons and estuaries. Use of the same methods allows direct comparison with past data and provides a number of reference sites for future comparisons.

In collecting data, depth of the sediment sample and methods used to separate invertebrates from the sediment are equally important. Benthic infauna are collected from sediments using coring devices. In most cases, the majority of infauna are collected from within the upper 2 to 5 cm of the sediment surface. Some larger, more mobile organisms can burrow to 60 cm, and longer coring devices are required for their capture.

Mesh size and sieving techniques influence density estimates. Monitoring efforts at Tijuana Estuary have employed two types of cores (5 cm and 20 cm in depth) and two mesh sizes for sieving (0.5-1.0 mm and 3mm). This allows for estimates of both shallow and deep-dwelling organisms. The 20-cm deep cores are sorted in the field with bivalves and crustaceans counted and released. Smaller organisms are fixed in the field in 10% ethanol and later identified in the laboratory.

Collection of replicate cores within each sampling station would be necessary in order to accurately sample invertebrate densities. At Tijuana Estuary, five cores per station were considered sufficient (Zedler et al. 2001).

Sorting and identification conducted in the laboratory may be time-consuming. These activities have been estimated to take up to 12 times that of initial sample collection (Saila et al. 1976 as cited in Zedler et al. 2001). Identification to genus and species increases the time and complexity of sorting. For the purposes of this study, taxa should be identified to at least the Family level to allow for comparison with PERL studies.

14.4.2 Fishes

Like invertebrates, fish can serve as useful indicators of the health of a system, both natural and constructed. Systems with impaired tidal circulation, high temperatures, increased freshwater input and other associated physical attributes often support a depauperate fish assemblage.

Typically, restoration projects assess fish habitat function by measuring fish occurrence or density. Although Zedler et. al (2001) point out that measuring species occurrence and abundance may not always accurately indicate habitat value, other measurements, such as growth rates, are labor intensive and expensive. When compared to similar monitoring at appropriate reference sites, fish species occurrence and abundance can be useful in evaluating the progress of the restored site. Like benthic invertebrates, selection of reference sites with similar physical attributes is essential. Factors such as hydrology and channel morphology are known to influence fish assemblages. Reference sites with similar habitats and landscape features must be identified.

Fish assemblages also vary in terms of composition and abundance over temporal scales. Like benthic invertebrates, species diversity and abundance is often lowest in winter months and highest in summer. Sampling should be planned to account for extremes in population structure. Therefore, it is recommended that sampling for fish be conducted during both the winter and summer simultaneously with benthic invertebrate sampling.

Fish sampling gear should be selected based on target species and habitats. Deep, subtidal areas should be sampled with otter or beam trawls which are towed behind a boat and sample a large area. Such nets produce quantitative estimates of fish populations although catch efficiencies can be low and species-selective.

In main tidal channels 0-2 meters in depth, fish assemblages have been quantitatively sampled with large beach seines. Beach seines have been used historically to sample the tidal channels of Tijuana Estuary. At each sampling site, two “blocking nets” (13.7 m long, 1.8 m deep, 3-mm mesh) are used to confine all fishes within a section of the channel. A beach seine (13.7 m long, 1.8 m deep, with a 2 X 2 m bag with 3-mm mesh) is drawn in a circular manner within the two blocking nets and pulled to shore. Hauls are repeated until the number of fish captured declines to near zero, usually 4-5 hauls. The blocking nets are then drawn together in a semi-circle to catch any fish that were hiding in the blocking nets (Nordby and Zedler 1991). These methods will be employed in the tidal channels created for this project.

All large fish will be identified, a subsample measured, and then released. Small fish, such as arrow goby (*Clevelandia ios*) can be problematic. Arrow gobies are extremely abundant in Tijuana Estuary at certain times of the year (spring and summer). However, there are other sympatric gobiid species that closely resemble arrow goby. These include shadow goby (*Quietula y-cauda*) and cheekspot goby (*Ilypnus gilberti*). As the three species may occur in the same habitat and total gobiids collected at a site may number in the thousands, it is recommended that a visual estimate of total gobiids be made and subsample fixed in the field for later identification in the laboratory. Once the ratio of the three species in the subsample has been determined, it can be applied to the total estimated catch. This avoids unnecessarily destructive sampling.

The sampling protocol described above should be considered a general guideline to be refined once the first phase of construction is identified and additional review initiated. Furthermore, once the monitoring plan is implemented, it should be reviewed and modified annually to ensure that the monitoring program is addressing the intended issues. For example, if monitoring fish growth rates in the newly created marsh becomes an objective, the monitoring plan should be modified to include these measurements.

14.4.3 Adaptive Management

Adaptive management can be defined as an experimental approach to restoration. This approach involves an iterative process in which scientists provide information and suggestions to resource managers, based on experimental results. Resource managers, in turn, incorporate this information into management plans and evaluate the application of this newly acquired knowledge with further research. In order to utilize an adaptive management approach for the Friendship Marsh project, the following actions are necessary:

- Incorporate experiments into the overall restoration plan
- Assess regularly the results of those experiments
- Identify problems and their sources
- Make adjustments to correct problems and their sources
- Continue to assess and adjust

For large projects like the Tijuana Estuary – Friendship Marsh, constructing the project in phases can be considered an adaptive management tool. Lessons learned from construction of the first phase can be applied to the next phase. This form of adaptive management was employed following construction of the first two components of the Tijuana Estuary Tidal Restoration Project – the Oneonta Slough Tidal Linkage and Model Marsh. Experiments on plant diversity conducted at the Tidal Linkage were expanded at the Model Marsh. In addition, replicate plots with soil amendments and replicate areas with and without tidal creeks were incorporated into the design of the Model Marsh. Subsequently, information gathered from studies at the Model Marsh has been incorporated into the design of the Friendship Marsh. During monitoring of the Model Marsh the following patterns were detected:

- Even with the Goat Canyon sediment basins, sediment that is already in the system continues to impact the southern portion of the estuary. This sediment is mobilized during rainstorms and will affect restoration until it is conveyed to the nearshore environment.

- Due to the inevitable sediment movement, restoration plans need to incorporate measures to accommodate and eliminate sediment that may become deposited.

- Due to the relative flatness of the southern estuary, even small berms (3 feet high) protect excavated marsh areas from water-borne sediment.

- It is difficult to create and maintain complex systems of tidal creeks. Created creeks fill with sediment or migrate while tidal creeks develop naturally in areas of marsh plain designed with no tidal creeks.

- Channels should be excavated wide enough to avoid steep sides that may result in slumping of sediments into the channel.

- A relatively small increase in tidal prism, such as that offered by a 20-acre site constructed at 4.5 feet MLLW, can scour the natural channels that feed it, thereby removing sediment deposited during rain events and/or coincidental high tides.

- Newly exposed soils may develop hypersaline conditions that can affect large-scale plantings.

- The predicted natural recruitment of mid-marsh plants did not occur. Only pickleweed recruited naturally and at a much slower rate that predicted. Because of the patchy recruitment in the mid-marsh, this area functioned as mudflat supporting sandpipers and other species.

- Relatively small (20 acres) areas can attract target species, such as clapper rails. Up to 5 pairs of clapper rails were detected in the Model Marsh in spring 2004.

Based on the above, the current project has used adaptive management in the following ways:

- Large areas of open water were incorporated in anticipation of sediment deposition. These areas will serve to flush accumulated sediment out of South Slough Channel and increase tidal flushing to the south arm.

- These areas of open water will be overexcavated, i.e., excavated below their eventual target elevation, in order to accommodate the sediment that is in the system.

- The design of the project does not include small, complicated tidal creeks. Rather, it emphasizes relative large channels that lead off of the main open water feature. Small, dendritic channels are expected to develop naturally over time.

- A berm and weir that connects to the existing AmSod berm has been incorporated into the project design to protect the restored area from sediment borne by the Tijuana River.

- Project goals include creation of substantial areas of mudflat for shorebirds, low marsh for species such as clapper rail, and mid-high marsh for species such as Belding's savannah sparrow.

- The project design includes plans for installation of sediment fluidizers to remove accumulated sediment during high tide events.

- The project has been designed so that the first phase will be constructed in the most disturbed portion of the project area and progress into other areas. This will facilitate the concept of "self mitigation" wherein the first phase impacts disturbed land, restoring it to high quality wetlands before the next phase is constructed. Thus, the wetlands created from disturbed upland areas serve as mitigation for the impacts to disturbed wetlands in the next phase.

Restoration of Tijuana Estuary will require controlling sediment sources, regulating sedimentation to match the rate of sea level rise, recontouring land to sustain native habitat types, reducing the distribution of invasive species, and recovering lost species diversity. Historical conditions cannot be restored as permanent development has encroached on historical wetlands. Recovery of plant diversity must be active, with planting of rarer species and management of currently dominant species. Rising sea levels may push wetlands in the region inland at a relatively fast pace, potentially favoring weedier plant and animal species.

The immediate restoration goal is to recover as much wetland habitat as possible with the least cost. The creation of a variety of microhabitats can compensate for a lack of detailed information on the requirements of each plant or animal species of microhabitats (i.e., topographic heterogeneity). Specific recommendations for restoration include:

- Continually restore habitat modules so that some new habitat is always available for target species;
- Excavate areas converted to weedy uplands via sedimentation but avoid exposing large marsh plains all at once as salt crusts may inhibit seedling recruitment;
- Excavate cordgrass habitat adjacent to tidal channels; avoid creating broad cordgrass marshes, like those found on the Atlantic coast, where tidal regimes differ significantly.
- Design modules to include restoration experiments so that adaptive management can be incorporated to improve successful attainment of restoration targets.

General recommendations include:

- Create experimental marshes to test hypotheses regarding the distribution of salt marsh habitats (i.e., relative areas of open water, mudflat, low marsh, mid-high marsh).
- Examine different methods for creating tidal creeks, including full excavation versus excavation of only a small connection with the feeder channel, and documentation of natural tidal creation with no excavation.
- Plant mid-marsh elevations with the full suite of plants species with the exception of *Salicornia virginica*.
- Examine overexcavation as a means of accommodating anticipated sedimentation. Include islands of higher topography planted with the mid-marsh plant assemblage to serve as a source of propagules for eventual restoration once sediment has accumulated in overexcavated areas.

- Use indirect methods of determining the function of restored marshes, such as the use of trematodes that parasitize salt marsh snails.

- Incorporate topographical heterogeneity into experimental marshes to test the importance of pools and depressions on salt marsh plant establishment and survival.

- Examine the role of nitrogen limitation on the distribution of dominant halophyte plant species.

- Examine the role of plant species diversity on ecosystem function.

- Examine seasonality of opening created wetlands to tidal flushing with an emphasis on establishing tidal flushing at the time that most salt marsh plant species set seed.

14.5 The Southern California Integrated Wetlands Regional Assessment Program

In 2002, the Southern California Wetlands Recovery Project (WRP) endorsed a Science Advisory Panel (SAP) recommendation that a wetland regional monitoring program be developed for coastal southern California watersheds. It was determined that a regional monitoring program was needed because neither the progress of regional wetland recovery, nor the continued loss and degradation of wetlands, has been quantified in southern California, despite efforts in wetland monitoring. A regional wetlands assessment program provides a cost effective way to evaluate these trends in wetland areas and to assess the WRP's progress toward achieving its regional wetland recovery objectives. Uses of the data generated by the regional monitoring program include:

- Evaluating recovery priorities and progress;
- Allocating public funds in ways that result in lasting regional impact;
- Answering wetland management information questions;
- Streamlining reporting of monitoring data, making them more accessible for routine scientific evaluation of restoration and management techniques;
- Verifying the effectiveness of wetland regulatory and management policy.

In 2006, a position paper titled "Framework for Regional Assessment of All Wetland Classes and Indicators for Estuary and Coastal Lagoon Assessment: Recommendations by the Southern California Wetlands Recovery Project Science Advisory Panel" was produced. This paper provides a general framework for the southern California Integrated Wetlands Regional Assessment Program (IWRAP), as well as detailed recommendations for estuarine and coastal wetland monitoring. It was determined that a separate monitoring plan would need to be developed for estuarine, riverine, and depressional wetland classes. It was a recommended that program development focus on estuaries based on the amount of funding that the WRP had allocated to acquisition and restoration of estuarine systems. The following information and tools are available once IWRAP is implemented:

- Wetland Condition Data – Data relating to the status of, and trends in, southern California wetland conditions over time;

- Inventory – Maps of wetland and riparian habitat in southern California;
- Project Tracking – A record of project related changes in wetland and riparian habitat acreage over time;
- Monitoring Protocols – Standardized methods to monitor wetland extent and condition, and
- Information Management System – A database and information-management infrastructure for storing and sharing regional data with other user groups.

The IWRAP regional monitoring program is based on a three-tiered assessment that integrates monitoring at varying spatial scales and levels of intensity:

- Level 1 - consists of maps of wetlands habitat;
- Level 2 - measures resource condition and stressors on a regional scale;
- Level 3 - addresses detailed questions about stressors and condition on a site-specific scale. Restoration project monitoring is an example of a Level 3 assessment.

The proposed Tijuana Estuary – Friendship Marsh Restoration would be considered a Level 3 monitoring program. Level 3 monitoring facilitates an assessment of trends in the condition of a site over time and therefore provides information about the success of specific restoration efforts funded by the WRP and others. It can also yield insight into the spatial heterogeneity of certain indicators, such as contaminant and plant community composition within a given estuary. The final monitoring program will be developed in cooperation with the IWRAP framework plan to include the monitoring recommendations being developed by the SAP.

15.0 ADDITIONAL ANALYSES AND NEXT STEPS

During the course of preparing this feasibility and design study many issues were identified that could not be addressed due to time and funding constraints. In addition, there is an inherent uncertainty associated with any habitat restoration project. For example, the effects of global climate change and sea level rise create uncertainty with regards to achieving the desired functions of the restored estuary. Analyzing the potential effects of climate change, sea level rise and other project uncertainties required resources that were beyond those allocated to project. Therefore, these issues, although recognized as important, will be addressed in future phases of the project planning. This section provides an overview of important analyses that will need to be conducted in the near future as the next steps in the planning process. It is anticipated that these analyses will be conducted prior to or simultaneously with final engineering and environmental document preparation.

15.1 Global Climate Change

The 2007 Assessment Paper Report by the Intergovernmental Panel on Climate Change (IPCC) estimates that over the next century the mean temperature of the planet will increase by 2˚- 4˚ C with an associated sea level rise of between 20 and 60 cm. Based on these projections, the U.S Geological Survey (USGS) has identified the area between Point Conception and the Mexican Border as high to very high risk of adverse effects of sea level rise. In addition to sea level rise, global warming is predicted to affect precipitation patterns, with increased storminess relative to the past several decades.

These predictions have stimulated coastal states to begin developing management plans to address predicted changes, especially as they pertain to risks associated with flooding and erosion. Only recently have coastal planners begun assessing the effects of global change on coastal wetlands in general, and on the restoration of coastal wetlands in particular. In 2007, the Southern California Coastal Water Research Project (SCCWRP) proposed a study plan to address the impacts of global warming on coastal wetlands, using idealized, model systems. Although the timing of such studies was not compatible with the timing of this feasibility and design study, it has been generally agreed that the planned restoration at the TRNERR represents an excellent opportunity to translate model outcomes into decision-making and project implementation. This section summarizes the tasks outlined in the SCCWRP proposal prepared by Dr. Eric Stein, and its applicability to the current restoration project.

Predicting the effects of global climate change on coastal wetlands is a function of both the ocean and the watershed. As the oceans warm and polar ice melts, sea level rises. With increased storminess, i.e., increased intensity of winter storms as opposed to increased occurrence of storms, winter river flows increase and interact with rising sea level. Thus, any model used to predict the impact of global warming on a coastal wetland must address both physical factors and translate those physical parameters into biological responses. The following steps were recommended by SCCWRP for analyzing the effects of global climate change and its effects on southern California coastal wetlands.

1. Summarize Existing Information. Review and summarize recent studies of climate change for coastal southern California and conduct interviews with experts working in this field. Emphasis should be given to existing models of changes in temperature, sea level, rainfall and runoff.

2. Estimate Effects of Terrestrial Forcing Functions. Two primary terrestrial forcing functions – run off (including storm and non-storm run off) and sedimentation - should be investigated, including, using a synthetic watershed approach. These synthetic watersheds will represent a range of physical conditions that exist in southern California. Once the synthetic watersheds are constructed, long-range multi-decadal simulations should be run on both sediment and water discharge. By using synthetic watersheds, the investigators can vary features such as soil type, evapotranspiration, slope, depth to ground water and storage capacity to predict how these parameters affect runoff and sediment yield.

3. Estimate Effects of Oceanic Forcing Functions. A series of synthetic oceanic models should be constructed to assess changes in key oceanic physical factors. These include such factors as coastal geomorphology, sea level rise and shoreline accretion and erosion. A dynamic model should be used to simulate the effect of runoff, tides, and sediment deposition or erosion on estuary depth, salinity, mean water height, bottom elevation and pore-water salinity.

4. Characterize Expected Change in Wetland Extent and Distribution, including biological responses to climate change. The focus of this step should be to predict changes in wetland extent and distribution including changes in inundation, scour and sedimentation. This should be accomplished through the use of contemporary mapping, historical data and interviews with regional experts.

Tijuana Estuary, perhaps more than any other southern California lagoon or estuary, faces immediate, short-term challenges related to sediment deposition. However, like other southern California systems, sea level rise represents a long-term challenge to restoration. Perhaps the only management method that can integrate both short-term sedimentation and long-term sea level rise is adaptive management. It is anticipated that the restoration project will be constructed in several phases, each requiring detailed engineering plans, environmental documentation, permitting, and funding (see Section 11). Previous restoration projects at Tijuana Estuary, including the Oneonta Slough Tidal Linkage and Friendship Marsh (or Model Marsh), have required an average of approximately 7 years from final engineering through construction. This timing allows for focusing on sediment accretion in the initial stages of the project and integrating sea level rise as it occurs. Under this scenario, the first phase would be overexcavated as presented in Section 11. Once this phase has been constructed and monitored for several years, additional data on sea level rise will be available to incorporate into final design of the second phase. Subsequent phases could be designed to be under-excavated to incorporate sea level rise. The initial phase or phases may be converted to shallow subtidal habitat over time, a valuable resource, if not the original target. In the interim, the initial phase or phases will provide refugia for plants and animals that are currently in danger of extirpation, both on local and regional scale.

15.2 Additional Engineering and Environmental Tasks

The preferred restoration alternative presented in this feasibility and design document is essentially conceptual - it has been engineered to a level of detail of approximately 30% of that required to acquire a grading permit and other permits for regulatory agencies. This level of detail allows for estimates of the volume of material to be excavated, disposal options and the costs associated with these project activities. However, prior to construction of the first phase, or the entire project, additional engineering and environmental analyses must be conducted. These include:

- Refinement of project engineering;
- Additional sediment testing;
- Selection and/or refinement of recreational trails;
- Preparation of required environmental documents (EIR or EIS);
- Acquisition of discretionary permits; and
- Preparation of bid documents.
- Update habitat mapping of the entire estuary

It is anticipated that these additional analyses will be conducted as part of the project EIR/EIS.

15.2.1 Refinement of Engineering Plans

Final engineering plans will require development of detailed horizontal and vertical survey control, preparation of plan views and cross-sections of excavated areas, quantification of soils to be excavated, preparation of a final disposal plan for excavated sediments, and preparation of final bid documents, including the engineers' cost estimate. These final plans are tied to the result of other final analyses, especially supplemental sediment testing.

Final engineering plans may also include design changes. Currently, the preferred alternative incorporates a large open water body and significant intertidal mudflat and salt marsh components. While major modifications to this design are not anticipated, minor design changes may be required as a result of additional subsurface investigations and recreational trail alignment. For example, it was suggested that large areas of low marsh should include a series of smaller, intertidal creeks rather than a broad marsh plain. Thus, final design may include detailed creek networks. These design changes will be incorporated into the final environmental document.

The project, as designed, would be constructed in phases. As presented in Section 11, those phases include square-shaped units. The current square-shaped design will likely be modified during final design to include contours that resemble those found in nature.

15.2.2 Sediment Testing

The feasibility and design study included a limited analysis of the sediment of the project area, including twenty-four 20-foot deep soil borings and 49 backhoe trenches. Soil borings were separated by strata and analyzed for grain size distribution. Six composited surface strata were analyzed for chemical constituents. The results of the sediment analysis indicated a heterogeneous distribution of sediment grain sizes and moderate levels of DDT derivatives in two composited surface samples. These results do not support a final disposal plan and additional data are needed to demonstrate grain size compatibility with receiver sites (if possible) and to delineate and isolate the areas demonstrating the presence of DDT derivatives. The results of these additional investigations will affect final design, sediment disposal, permitting and cost.

15.2.3 Recreational Trails

Three alternative multi-use trails were identified in the feasibility and design study, with preliminary engineering provided for the beach access trail alternative (Section 10). Responses from the Scientific Advisory Committee, regulators and public were varied with most scientists vigorously opposed to dissection of the restored area by the trail. Additional analyses of potential trail alignments are required, including an equal level of engineering and environmental analysis. The California State Parks is committed to providing beach access to the public during and after project construction. It is anticipated that additional trail analyses will be conducted as part of the EIR process. Final trail selection will affect final design and cost.

15.2.4 Environmental Documentation

An Environmental Impact Report (EIR) pursuant to the California Environmental Quality Act (CEQA) will be required prior to construction of the phased project. An EIR requires analysis of project alternatives and provides a process for public comment. It is anticipated that the California State Parks (CSP) will act as the lead agency and that the U.S. Fish and Wildlife Service, the California Coastal Commission, and the cities of Imperial Beach and San Diego and perhaps other agencies will participate as cooperating agencies.

It is anticipated that a programmatic level EIR will be prepared that addresses the entire project. However, as future phases may be modified to address such issues as sea level rise, supplemental environmental documentation may be needed. The timeframe for preparation of a draft EIR, response to comments, issuance of a final EIR and final approval typically takes about one year.

CEQA provides for public review of the project EIR, including review by public agencies. Individuals and groups may challenge the adequacy of the EIR based on the requirements of CEQA. Legal challenges may result in design changes and, ultimately, an increase in the time required for final approval.

15.2.5 Discretionary Permits

A number of discretionary permits will be required from regulatory agencies prior to construction of each phase of the project. These include permits for excavation and disposal of sediments, development permits from the City of Imperial Beach, and consultations with the wildlife agencies regarding impacts to listed threatened or endangered species. Permits required for excavation and disposal of sediment include a Section 404 (Clean Water Act) permit from the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency; a Section 1600 (Fish and Game Code) Stream Bed Alteration Agreement from the California Department of Fish and Game (CDFG); and a Section 401 (Clean Water Act) Water Quality Certification from the California Regional Water Quality Control Board. Potential project impacts to state- and federally-listed plant and animal species will require consultation with the U.S. Fish and Wildlife Service (USFWS) pursuant to Section 7 of the Federal Endangered Species Act and, potentially, consultation with the CDFG pursuant to Section 2081 of the California Endangered Species Act. Initial discussions indicate that informal consultation with the USFWS will suffice as the proposed timing of the project will avoid the breeding season of sensitive avian species and will avoid impacts to listed plant species. A Biological Opinion (BO) rendered by the USFWS is the end point of both informal and formal federal consultation. The CDFG may choose to combine the 2081 process with the Section 7 process. Consultation may be initiated based on plans that are not yet finalized; however, final engineering plans and a final EIR must be prepared prior to issuance of the BO.

The California Coastal Commission (CCC) requires a Coastal Development Permit for any project that is proposed within that agency's jurisdiction. The restoration project is located within the Coastal Commission's jurisdiction.

15.2.6 Bid Documents

The final step in project planning is the preparation of bid documents and the solicitation of bids for contractors. Bid documents should be based on an approved EIR and include all appropriate permits and consultations. Typically, bid documents are prepared by the project engineer. Bid documents incorporate project engineering plans, habitat restoration plans, contractor's restrictions, and warrantees. The project is advertised to potential contractors with the project awarded to the lowest qualified bidder. The project engineer also provides a cost estimate by which the bidder's costs are evaluated. In the event that the engineer's cost estimate is greatly exceeded by all or most contractors' estimates, the bid process may be cancelled and reissued upon modification.

15.2.7 Habitat Mapping

As presented in Section 2.2 Historical Ecology, the most recent habitat map prepared for Tijuana Estuary was compiled in 1986. In order to accurately document changes that have occurred, including habitat lost to sediment deposition and habitat gained by restoration projects, an updated mapping effort will be undertaken. This effort will be to the level of detail of the 1986 map in order to make direct comparisons.

15.3 Fate and Transport Study

The Tijuana Estuary – Friendship Marsh Restoration, Feasibility and Design Study was expanded in 2007 to support an effort by the U.S. Geological Survey (USGS) to study the fate of fine-grained sediment once it enters the nearshore environment. This study was designed to address the applicability of a commonly applied standard for disposal of sediments in the ocean – the 80-20 standard. The 80-20 standard requires that sediment disposed in the ocean consist of 80% coarse material and no more than 20% fines. This standard was originally used as a threshold for determining whether pollutants, that are typically attached to fine grained materials, would be of concern for ocean disposal projects. The 80-20 standard has been expanded to include clean sediment with extensive/long-lasting turbidity and burial of species/habitat typically cited as the reasons for concern.

The Fate and Transport Study is a small demonstration project proposed to assess the extent and duration of turbidity and burial when sediment with greater than 20% fines is used for opportunistic reuse (i.e., beach nourishment). The study was situated at Tijuana Estuary where there has been extensive loss of wetland habitats over the past few decades due to sedimentation. The study seeks to answer two major questions: 1) What are the transport pathways and impact of fine-grained sediment introduced at the shoreline? and, 2) How do environmental and project variables, such as sediment placement volume, percent fines, waves, currents, and shelf settling, influence the rates and modes of transport and eventual fate? Thorough physical and biological monitoring will be conducted to answer these questions.

The Fate and Transport Study proposes to place approximately 60,000 cubic yards of material composed of approximately 40% fines and 60% coarse material in the nearshore marine zone at Tijuana Estuary. The source of the sediment will be the debris basins at Goat Canyon maintained by California State Parks (CSP). This sediment is expensive for CSP to remove and dispose and could provide beneficial reuse as a supply for beach nourishment.

The USGS will follow the fate of the material as it is washed into the nearshore environment by the tide. The USGS will address the following questions:

1. What are the residence times and mechanisms of water turbidity due to the introduced fine sediment?
2. What are the residence times and mechanisms of sedimentation on the seabed due to the introduced fine sediment?
3. What are the sediment transport pathways that lead to the final sink for the fine sediment introduced into the nearshore?
4. How does project implementation (volume and rate of placement) influence ocean sediment transport and fate?
5. Will the coarser fraction of sediment added to the nearshore benefit the beach profile?

These questions will be addressed by monitoring the transport and fate of the sediment through sea floor mapping and plume mapping. Additional monitoring will be conducted by the consulting team. These include monitoring the potential project effects on burial of benthic organisms and interruption of bird foraging in the area of the plume.

The project is currently in the planning stages. A Sampling and Analysis Plan has been prepared for submittal to the USACE and USEPA and other regulatory agencies. An Initial Study was conducted pursuant to CEQA to determine what environmental impacts the project may have. Other studies are currently being conducted to support the project. Discretionary permits are required from a number of agencies before the project can be implemented. Environmental review will continue through the fall of 2008 with implementation scheduled for winter 2008.

Should the Fate and Transport study demonstrate that there is little or no impact from the disposal of fine material at Tijuana Estuary, it is possible that sediment excavated during construction of the restoration project could be disposed of in the nearshore environment. This would result in a substantial cost savings as the main costs for construction are associated with sediment disposal.

Table 15-1. Summary of Additional Studies and Next Steps

1. Address Effects of Climate Change
   - 1a. Summarize Existing Information
   - 1b. Estimate Effects of Terrestrial Forcing Functions
   - 1c. Estimate Effects of Oceanic Forcing Functions
   - 1d. Characterize Expected Change in Wetland Extent and Distribution
2. Refine Engineering
   - 2a. Incorporate Project Changes
   - 2b. Develop Horizontal and Vertical Control
   - 2c. Quantify amount of material to be excavated
   - 2d. Prepare Final Disposal Plan
   - 2e. Prepare Bid Documents and Engineers Cost Estimate
3. Conduct Additional Sediment Investigations
   - 3a. Analyze Additional Grain Size Samples
   - 3b. Conduct Additional Contaminant Screening
4. Address Recreational Trails
   - 4a. Conduct Equal Level of Engineering for All Alternatives
   - 4b. Select Preferred Alternative
5. Prepare Environmental Document (EIR)
   - 5a. Conduct Additional Analyses As Needed (e.g., air quality, water quality, traffic)
   - 5b. Prepare Draft EIR
   - 5c. Respond to Public Comments
   - 5d. Issue Final EIR
6. Prepare Discretionary Permit Applications
   - 6a. USACOE Section 404 Permit
   - 6b. RWCQB Section 401 Water Quality Certification
   - 6c. CDFG Streambed Alteration Agreement
   - 6d. CCC Coastal Development Permit
   - 6e. USFWS Section 7 Consultation
7. Prepare Updated Habitat Map
8. Conduct Fate and Transport Study
   - 8a. Evaluate Applicability to Restoration Plan

16.0 REFERENCES

Almstedt, Ruth F. 1982. Kumeyaay and `IIpay. In *APS/SDG&E Interconnection Native American Cultural Resources*, edited by Clyde M. Woods, pp. 6-20. Wirth Associates, Inc., San Diego.

AMEC Earth and Environmental. 2005a. *Final Tijuana Estuary Restoration Feasibility Study Sediment Characterization Study.*

AMEC Earth and Environmental. 2005b *Final Tijuana Estuary Restoration Feasibility Study Supplemental Grain Size Report, San Diego, CA*. Prepared for Tierra Environmental Services.

American Society for Testing and Materials. 1967. *Standard Methods for Grain Size Analysis of Soils*. ASTM Designation D422-63, Part II.

Atkins, M.D. 1978. *Insects in Perspective*. MacMillan Publishing Co., New York. 513 pp.

Bloom, A.L. 1983a. Sea level and coastal morphology of the United States through the Late Wisconsin glacial maximum. Pp. 215-229 in S.C. Porter, ed. The Late Pleistocene, Vol. I. of H.E. Wright, Jr., ed. *Late Quaternary environments of the United States*. University of Minnesota Press, Minneapolis.

Bloom, A.L. 1983b. Sea level and coastal changes. Pp. 42-51 in H.E. Wright, Jr., ed. The Holocene, Vol II. of H.E. Wright, Jr., *Late-Quaternary environments of the United States*. University of Minnesota Press, Minneapolis.

BSI Consultants. 1994. *Two Alternatives Report: Tijuana River Valley flood control and infrastructure study*. Prepared for the City of San Diego Tijuana River Valley Task Force.

Byrd, Brian F. 1998. Harvesting the Littoral Landscape During the Late Holocene: New Perspectives from Northern San Diego County. *Journal of California and Great Basin Anthropology* Volume 4 (2): pp. 195-218.

California Department of Fish and Game. 2001. Coastal Wetlands – Emergent Marshes, in *California Living Marine Resources: A Status Report*, California Department of Fish & Game, pp. 483-486.

California State Lands Commission. 2001. U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers. *Final EIR/EIS for the Bolsa Chica Lowlands Restoration Project*.

Chang, H. H. 1988. The Fluvial 12 Model, in *Fluvial Processes in River Engineering*, John Wiley & Sons, New York, NY, 432 pp.

Chang, H. H. 2004. *Hydraulics and sedimentation study for marsh restoration in Tijuana River Estuary*, prepared for Tierra Environmental Services, 55 pp.

Christenson, Lynne. 1992. The Late Prehistoric Yuman Settlement and Subsistence System: Coastal Adaptation. In *Essays on the Prehistory of Maritime California*, edited by T. Jones, pp. 217-230. Center for Archaeological Research at Davis Publication Number 10, University of California, Davis.

California Native Plant Society. 2001. *Inventory of Rare and Endangered Plants of California* (sixth edition). Rare Plant Scientific Advisory Committee, David P. Tibor, Convening Editor. Sacramento, CA. 338 pp.

CONCUR. 2000. *Comprehensive Management Plan for Tijuana River National Estuarine Research Reserve and Tijuana Slough National Wildlife Refuge*. CONCUR Inc. July.

Daly, H.V. 1978. *Introduction to Insect Biology and Diversity*. McGraw-Hill Book Co., New York, NY. 564 pp.

de Treville, Susan. 1984. *Wastewater Management Evaluation for the Tijuana River Estuarine Sanctuary*. Southwestern Wetlands Interpretive Association.

Ehrlich, P. R., D. S. Dobkin and D. Wheye. 1988. *The Birder's Handbook.* Simon and Schuster, Inc., New York, NY.

ENTRIX, Pacific Estuarine Research Laboratory, and Phillip Williams & Associates. 1991. *Draft EIR/EIS Report, Tijuana Estuary Tidal Restoration Program, Volume II*: Hydrologic Appendices.

Flick, R. E. and D. R. Cayan. 1984. Extreme sea levels on the coast of California, *Coastal Eng. Proceedings of the 19th Intl. Conf. (Houston)*, Amer. Soc. Civil Eng., New York, pp. 886 –896.

Gallegos, C.L. 1992. *Photosynthesis, productivity, and species composition in an eutrophic sub-estuary: Composition of bloom and bon-bloom assemblages*. Marine Ecology Progress Series 81: pp. 257-267.

Gifford, E.W. 1931. *The Kamia of Imperial Valley*. Bureau of American Ethnology, Bulletin 98.

Goodwin, P. and J. Florsheim. 1997. *Preliminary hydrologic evaluation of modified alternatives B*. Phillip Williams and Associates, Report #PWA-1154, submitted to the Southern California Edison Company. 26 pp.

Group Delta Consultants. 1999. *Drainage Study Goat Canyon and Reclamation of Gravel Quarry Site*, *Tijuana River National Estuarine Research Reserve*, Prepared for California State Coastal Conservancy, Project No. 1908. San Diego, California.

Hedges, K. 1975. Notes on the Kumeyaay: A Problem of Identification. Journal of California Anthropology, 2 (1), pp. 71-83.

Hickman, J. C. 1993. *The Jepson Manual - Higher Plants of California*. University of California Press, Berkeley and Los Angeles, California.

Hicks, F. N. 1963. *Ecological Aspects of Aboriginal Culture in the Western Yuman Area*. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Los Angeles, CA.

Holland, R. F. 1986. *Preliminary Descriptions of the Terrestrial Natural Communities of California*. State of California, The Resources Agency, Department of Fish and Game, Non-game Heritage Program, Sacramento, CA.

Homziak, J. 1977. *Substrate Relationships and Competition Among Three Species of Callianassid Shrimp*. M.S. Thesis. San Diego State University, San Diego. 160 pp.

Hosmer, S. C. 1977. *Pelecypod-sediment Relationships at Tijuana Estuary*. M.S. Thesis, San Diego State University, San Diego. 115 pp.

Inman, D. L. 1960. Shore Processes, *McGraw-Hill Encyclopedia of Science and Technology*, v. 12, pp. 299-306.

Inman, D.L. and S.A. Jenkins. 1983. *Oceanographic Report for Oceanside Beach Facilities*, prepared for the City of Oceanside, Oceanside, CA. August 1983, 206 pp.

Inman, D.L. and P.M. Masters. 1991. Budget of Sediment and Prediction of the Future State of the Coast, Chapter 9 (105 pp.) in *State of the Coast Report, San Diego Region, Coast of California Storm and Tidal Waves Study*, U.S. Army Corps of Engineers, Los Angeles District, Chapters 1-10, Appendix A-1.

James Dobbin & Associates. 1986. *Tijuana River National Estuarine Sanctuary Management Plan*.

Jenkins, S.A., D.L. Inman & J.A. Bailard. 1980. Opening and Maintaining Tidal Lagoons and Estuaries. *Proceeds of 17th Int. Coastal Eng. Conference, Amer. Soc. Civil Eng*., v. 2, pp. 1528-1547.

Jenkins, S.A., J. Wasyl and D.W. Skelly. 1992. Tracked Trapped Sediments, *Civil Engineering,* v. 62, n. 2, pp. 61-64.

Josselyn, M. and A. Welchel. 1999. *Determining the Upper Extent of Tidal Marsh Habitat, San Dieguito Lagoon*, submitted to Southern California Edison Company, 16 pp.

Kennedy, M.P. and S.S. Tan. 1975. *Map Showing Character and Recency of Faulting in the San Diego Area, California*. State of California Resources Agency, Division of Mines and Geology.

Kennedy, Michael P. and Siang S. Tan. 1977. *Geology of National City, Imperial Beach, and Otay Mesa Quadrangles, Southern San Diego Metropolitan Area, California*. California Division of Mines and Geology Map Sheet 29. Sacramento.

Kroeber, A. L. 1925. Handbook of the Indians of California. *Bureau of American Ethnology Bulletin 78*. Smithsonian Institute, Washington. Reprinted in 1976 by Drover Publications, New York, NY.

Kus, B.E. and P. Ashfield. 1989. Bird Use of the Tijuana Estuary. Unpublished report. San Diego State University, San Diego, CA.

Lemm, J. M. 2006. *Field Guide to Amphibians and Reptiles of the San Diego Region*. California Natural History Guide Series No. 89. University of California Press, Berkeley and Los Angeles, CA.

Long, E.R., D.D. Mac Donald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. *Environmental Management*, Vol. 19 (1). pp. 81-97.

Luomala, Katherine. 1976. Flexibility in Sib Affiliation among the Diegueño. In *Native Californians: A Theoretical Retrospective*, edited by L. J. Bean, and T. C. Blackburn, pp. 245-270. Ballena Press, Socorro, New Mexico.

Luomala, Katherine. 1978. Tipai-Ipai. In California, edited by Robert Heizer, *Handbook of North American Indians: California*. Smithsonian Institution, Washington, D.C. Vol. 8. 20 volumes.

Montgomery, S.J. 1995. *Results of Live-trapping Survey and Habitat Assessment for the Federally Endangered Pacific Pocket Mouse (Perognathus longimembris pacificus) in the Study Area for the South Bay Water Reclamation Plant and Dairy Mart Road and Bridge Improvements Project, Tijuana River Valley, San Diego, California*. Unpublished Report for Tierra Environmental Services.

Moratto, Michael. 1984. *California Archaeology*. Academic Press, San Diego, CA.

Nagano, C.D. 1982. *The Population Status of Seven Species of Insects Inhabiting Tijuana Estuary National Wildlife Refuge, San Diego County, California*. Report to the Office of Endangered Species.

Nicol, Donald W. 1971. *History of Border Field State Beach*. Report prepared by the State Park Historian. On file at California State Parks Southern Service Center, San Diego, CA.

Nordby, C.S. 1982. *The Comparative Ecology of Icthyoplankton Within Tijuana Estuary in Adjacent Nearshore Waters*. M.S. Thesis, San Diego State University. 101 pp.

Nordby, C.S. 1987. Response of Organisms to Estuarine Closure and Substrate Disturbance. In: *Proceedings of the Society of Wetland Scientists*; Eighth Annual Meeting, May 26-29, 1987, Seattle, Washington. pp. 318-321.

Nordby, C. S. and J.B. Zedler. 1991. Responses of Fish and Macrobenthic Invertebrate Assemblages to Hydrologic Disturbances in Tijuana Estuary and Los Peñasquitos Lagoon, California. *Estuaries*, 14(1): pp. 80-93.

Pacific Estuarine Research Laboratory. 2002. *Tijuana River National Estuarine Research Reserve: Annual Report on Ecosystem Monitoring*, NOAA Technical Memorandum, Washington, DC.

Peterson, R. T. 1990. *Peterson Guide to Western Birds*, Third Edition. Houghton Mifflin, Boston, Massachusetts.

Phillips, George Harwood. 1975. *Chiefs and Challengers: Indian Resistance and Cooperation in Southern California*. University of California Press, Berkeley, Los Angeles, and London.

Phillip Williams and Associates. 1987. *Tijuana Estuary Enhancement Hydrologic Analysis*, prepared for the Tijuana Estuary Tidal Restoration Program.

Phillip Williams and Associates. 2000. *Preliminary Draft, Goat Canyon Sediment Retention Basin Alternative Development*.

Pombo, O.A 2000. Water Use and Sanitation Practices in peri-urban areas of Tijuana: A demand side perspective. pp. 2656-294. in L.A. Herzog, editor. *Shared Space: Rethinking the U.S. Mexico Border Environment*. Center for U.S. Mexican Studies, University of California, San Diego, San Diego, CA.

Port of San Diego. 2002. *Final Report –Central San Diego Bay Navigation Channel Deepening Project. Dredged Material Characterization*. April

Pryde, P.R. 2004. The Most Essential Resource: Water Supply for the County. pp. 125-140. in P.R. Pryde editor. *San Diego: an Introduction to the Region*. Sunbelt Publications, San Diego, CA.

Reiser, C. 1994. *Rare Plants of San Diego County.* Aquifer Press, Imperial Beach, CA.

Rensch, Hero E. 1975. *The Indian Place Names of Rancho Cuyamaca*. Acoma Books, Ramona, California.

Rice, C.D., F.A. Espourteille, and R.J. Huggett. 1987. Analysis of Tributyltin in Estuarine Sediments and Oyster Tissue, Crassostrea viginica. *Applied Organometallic Chemistry,* 1, pp. 541-544.

Rogers, Malcolm J. 1945. An Outline of Yuman Prehistory. *Southwestern Journal of Anthropology*, 1(2): pp. 157-198.

Regional Water Quality Control Board. 1994. *Water Quality Control Plan for the San Diego Basin* (9) Appendix D.

Saila, S.B. et al. 1976. Optimum allocation strategies for sampling benthos in the New York bight. *Estuarine, Coastal and Marine Science*. (4) pp. 119-128.

Shackley, M. Steven. 1984. *Archaeological Investigations in the Western Colorado Desert*: A Socioecological Approach, Vol. 1. Wirth Environmental Services, A Division of Dames & Moore, San Diego.

Shipek, Florence. 1982. The Kamia. In *APS/SDG&E Interconnection Project: Native American Cultural Resources*, edited by Clyde Woods, Wirth Associates, Inc., San Diego. pp. 21-33.

Sibley, A.S. 2000. *National Audubon Society The Sibley Guide to Birds*. Chanticleer Press, Alfred A. Knopf, New York, NY.

Spier, Leslie. 1923. Southern Diegueño Customs. *University of California Publications in American Archaeology and Ethnology* 20: pp. 292-358.

Southwest Wetlands Interpretive Association, Phillip Williams & Associates, Land Restoration Associates, and Tierra Environmental Services. (1999). *Goat Canyon/Cañon de los Laureles Enhancement Plan*. June.

Taylor, E. W. and J. Tiszler. 1989. *The Mammals of the Tijuana Estuary*. Report prepared for Pacific Estuarine Research Laboratory for the Tijuana Estuary Tidal Restoration Program.

TEG Oceanographic Services. 1999. *Report on Grain Size and Chemistry Data for Tijuana Estuary Samples*.

Tierra Environmental Services. 1999. *Cultural Resources Evaluation of Site CA-SDI-14,831 for the Tijuana Estuary Restoration Project/Model Marsh, Border Field State Park, California*. Prepared for the California State Coastal Conservancy.

Tierra Environmental Services. 2000. *Working draft Environmental Impacts Statement and Environmental Impact Report for the Goat Canyon Enhancement Plan Project*.

Tierra Environmental Services. 2002. *Biological Assessment for the Goat Canyon Enhancement Project*.

Tierra Environmental Services. 2003. *Proposal to Conduct Tijuana Estuary-Friendship Marsh Restoration Feasibility and Design Study*.

True, D.L. 1966. *Archaeological Differentiation of Shoshonean and Yuman Speaking Groups in Southern California*. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Los Angeles, California.

True, D.L. 1970. *Investigation of a Late Prehistoric complex in Cuyamaca Rancho State Park, San Diego County, California*. University of California Archaeological Survey, Los Angeles, California.

Unitt, P. 1984. *The Birds of San Diego County*. San Diego Natural History Museum. Ibis Publishing Co. San Diego, CA.

Unitt, P. 2004. *San Diego County Bird Atlas*. San Diego Natural History Museum. Ibis Publishing Co. San Diego, CA.

U.S. Army Corps of Engineers Los Angeles District (USACE). 2002. Final Environmental Impact Statement-Environmental Impact Report (EIS/EIR) – Proposed Imperial Beach Shore Protection Project, Imperial Beach, San Diego County, California.

U.S. Department of Agriculture (USDA). 1973. *Soil Conservation Service and Forest Service. Soil Survey San Diego Area, California*. Part I & II.

USDA. 2000. *Predator Management Report for Tijuana Slough National Wildlife Refuge*, South San Diego Bay National Wildlife refuge, and Border Field State Park.

U.S. Environmental Protection Agency EPA/USACE. 1998. *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S., Testing Manual: Inland Testing Manual*.

U. S. Fish and Wildlife Service (USFWS). 1996. Salton Sea National Wildlife Refuge Summary of 1996 Avian Botulism Event at INTERNET URL http://www.fws.gov/pacific/salton/slatn96.htm

USFWS. 1998. *Pacific Pocket Mouse Survey*, *Tijuana Slough National Wildlife Refuge*. San Diego, CA.

U.S. Geological Survey. 1977. USGS Digital Data Series DDS-37. INTERNET http://www.rvares.er.usgs.gov/wgn96cd/wgn/wq/region18/hydrologicunitcode

Willey, G. R. and P. Phillips. 1958. *Method and Theory in American Archeology*. University of Chicago Press, Chicago, IL.

Williams, P. B. and M. L. Swansen. 1987. *Tijuana Estuary Enhancement Hydrologic Analysis*. Prepared for the Tijuana Estuary Tidal Restoration Program. 50 pp.

Williams, K.S., M. Busnardo, D. W. Gibson, K. M. Johnson, and S. A Snover. 1989. *Terrestrial Anthropods of Tijuana Estuary*. Report Prepared for Pacific Estuarine Research Laboratory for the Tijuana Estuary Tidal Restoration Program.

Wood, F. J. 1986. *Tidal dynamics: coastal flooding, and cycles of gravitational force,* Kluwer Academic Publishers, 558 pp.

Wright R. W. 2005. *Tijuana River Atlas*. Joint Project between the Department of Geography and the Institute for Regional Studies of the Californias, San Diego State University, San Diego, CA.

Zedler, J.B. and C.S. Nordby. 1986. *The Ecology of Tijuana Estuary, California: A National Estuarine Research Reserve*. NOAA Office of Coastal Resource Management, Sanctuaries and Reserves Division, Washington D.C. 104 pp.

Zedler, J.B., C.S. Nordby, and B. Kus. 1992. *The Ecology of Tijuana Estuary: A National Estuarine Research Reserve*. Pacific Estuarine Research Laboratory (PERL). San Diego State University, San Diego, CA.

Zedler, J.B. ed. 2001. *Handbook for Restoring Tidal Wetlands*. CRC Marine Science Series, CRC Press, Boca Raton, FL.